XXX Conference
Polish Chitin Society
Łódź
September, 24-26th, 2025

NEW ASPECTS ON CHEMISTRY AND APPLICATION OF CHITIN AND ITS DERIVATIVES


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XXX Conference of Polish Chitin Society

"NEW ASPECTS ON CHEMISTRY AND APPLICATION OF CHITIN AND ITS DERIVATIVES.

Chitin, chitosan, and other polysaccharides"

Łódź, Poland
September 24-26th 2025
Polish Chitin Society

"NEW ASPECTS ON CHEMISTRY AND APPLICATION OF CHITIN AND ITS DERIVATIVES.

Chitin, chitosan, and other polysaccharides"

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XXX Conference of Polish Chitin Society

„NEW ASPECTS ON CHEMISTRY AND APPLICATION OF CHITIN AND ITS DERIVATIVES. Chitin, chitosan, and other polysaccharides"

CONFERENCE SCHEDULE

Sessions A, C, D, and E - "Gwiazdowa" conference room, first floor
Session B (poster session) - "Fabryczna" conference room, ground floor

September 24th 2025 – Wednesday

17^{00}-19^{00}	**Registration**
19^{00}-20^{00}	**Dinner**

September 25th 2025 – Thursday

9^{00}-9^{30}	**OPENING CEREMONY** **Katarzyna Struszczyk-Świta, Ph.D., President of PTChit**
	Prof. Henryk Struszczyk prize - giving ceremony

		SESSION A **ORAL PRESENTATION**
Chairman		**Prof. Małgorzata JAWORSKA, Ph.D., D.Sc.**
A1	**9^{30}-9^{50}**	**Irina Kuznik, Sabrina Scheele, Chokri Cherif, Katja Heppe, Moritz Gold, Jonas Finck, Axel Wähling, Barbara Zippel, Ina Turinsky, Mareike Gast** **INSECTMATTER: INSECT-BASED CHITIN FOR REGIONAL BIOECONOMY**
A2	**9^{50}-10^{10}**	**Katarzyna Gurzawska-Comis, Salwa Suliman, Anna Mieszkowska, Bodil Jørgensen, Kamal Mustafa** **SUSTAINABLE PLANT POLYSACCHARIDE-BASED BIOMATERIALS FOR BONE REGENERATION IN AGING POPULATION**
A3	**10^{10}-10^{30}**	**Olga Marchut-Mikołajczyk, Piotr Drożdżyński** **NATURAL ENZYME FACTORIES: CHITOSANOLYTIC ACTIVITY IN FUNGI FROM *CHELIDONIUM MAJUS***
A4	**10^{30}-10^{50}**	**Piotr Drożdżyński, Olga Marchut-Mikołajczyk** **A DUAL-ACTION BIOPREPARATION: ENDOPHYTIC BIOSURFACTANTS AND CHITOSAN FOR CROP STIMULATION**
A5	**10^{50}-11^{00}**	**Magdalena Gierszewska** **PROGRESS ON CHEMISTRY AND APPLICATION OF CHITIN AND ITS DERIVATIVES**
11^{00}-11^{20}		**Coffee/tea break**

11^{20}-12^{20}	**SESSION B** **POSTER PRESENTATION**
B1	**Katarzyna Małolepsza-Jarmołowska, Hanna Bazan** **STUDY OF THE EFFECT OF POLYVINYLPYROLIDONE K-15 ON THE PROPERTIES OF CHITOSAN GELS PREVENTING THE EFFECTS OF REFLUX**
B2	**Katarzyna Małolepsza-Jarmołowska, Hanna Bazan** **CHITOSAN GELS PROTECTING THE ESOPHAGEAL MUCOSA CONTAINING A THERMOSENSITIVE POLYMER IN THE PRESENCE OF HYDROPHILIZING SUBSTANCES**
B3	**Anna Marzec, Bolesław Szadkowski, Zbigniew Draczyński, Dominik Sikorski** **SUSTAINABLE BIOACTIVE FORMULATION FOR ECO-FRIENDLY COTTON: ENHANCING ANTIMICROBIAL EFFICACY AND FIRE RESISTANCE**
B4	**Renata Czechowska-Biskup, Klaudia Jakubowska, Malwina Olejniczak, Bożena Rokita, Piotr Ulański** **SONOCHEMICAL SYNTHESIS OF CHITOSAN-STABILIZED SILVER NANOPARTICLES**
B5	**Aleksandra Dziopa, Oskar Zimak-Krótkopad, Judyta Cielecka-Piontek** **EXTRACTION AND CHARACTERIZATION OF CHITOSAN FROM DIFFERENT SILKWORM SPECIES**
B6	**Urszula Filipkowska, Tomasz Jóźwiak** **EFFICIENCY OF THE REACTIVE BLACK 5 DYE REMOVAL IN AN AIR-LIFT REACTOR AND IN A COLUMN REACTOR**
B7	**Małgorzata Gnus** **MIXED MATRIX CHITOSAN MEMBRANES – INFLUENCE OF METAL OXIDE PARTICLES ON WATER AND ETHANOL TRANSPORT PROPERTIES IN VAPOUR PERMEATION PROCESS**
B8	**Barbara Hawrylak-Nowak, Sławomir Dresler, Jan Sawicki, Renata Matraszek-Gawron, Maria Stasińska-Jakubas, Katarzyna Rubinowska, Weronika Woch** **A COMPARATIVE EVALUATION OF THE ABILITY OF TWO CHEMICAL FORMS OF CHITOSAN TO ALLEVIATE SALINITY-INDUCED STRESS IN *CUCUMIS SATIVUS L.***
B9	**Karolina Rolińska, Ewelina Jakubowska, Katarzyna Łęczycka-Wilk, Małgorzata Żmieńko, Szymon Mania, Adrianna Banach-Kopeć** **BIOACTIVE CHITOSAN FILMS WITH DEEP EUTECTIC SOLVENTS AND FRUIT WASTE EXTRACTS FOR IMPROVED FOOD PACKAGING PROPERTIES**
B10	**Agata Krakowska, Joanna Zontek-Wilkowska, Dominik Műller, Żaneta Binert-Kusztal** **PERSONALIZED HYDROGEL DRESSING DOPED WITH BIOACTIVE SUBSTANCES - DERIVED FROM BIOMASS *IN VITRO* CULTURES**
B11	**Joanna Zontek-Wilkowska, Agata Krakowska, Dominik Műller, Przemysław Dorożyński** **USE OF EXTRACTED POLYSACCHARIDES FROM PLEUROTUS SPP. BIOMASS TO OBTAIN BIOACTIVE LAYERS**

B12	**Dominik Műller, Beata Paczosa-Bator, Joanna Zontek-Wilkowska, Bożena Muszyńska, Agata Krakowska** **EFFECTIVE CHEMICAL METHOD OF CHITOSAN EXTRACTION FROM *IN VITRO* CULTURES OF *LENTINULA EDODES***
B13	**Jacek Nowaczyk, Magdalena Gierszewska, Ewelina Jakubowska** **THE STUDY OF CHITOSAN BETAINE-CYTRIC ACID COMPLEX INTERMOLECULAR INTERACTIONS USING DFT**
B14	**Katarzyna Pieklarz, Zofia Modrzejewska** **CHITOSAN BIOMATERIALS CONTAINING SALT OF PYRIMIDINE NUCLEOTIDE – PHYSICOCHEMICAL ASSESSMENT AND *IN VITRO* BIOCOMPATIBILITY ANALYSIS**
B15	**Maria Wiśniewska-Wrona, Monika Sikora, Anna Wojtala, Marek Warzała, Klaudia Piekarska, Konrad Sulak, Dominik Borkowski, Wiesław Adamiec, Dorota Stańczyk** **OBTAINING VARIOUS FUNCTIONAL FORMS FROM PLASTICIZED CHITOSAN BY EXTRUSION TECHNIQUE**
B16	**Monika Bil, Wiktoria Luba, Bartłomiej Bukryj, Wiktoria Pietraszuk, Maciej J. Bernacki, Artem Kuchalenko, Tomasz Ciamulski** **3D STRUCTURED CELLULOSE PADS FUNCTIONALISED WITH VARIOUS POLYSACCHARIDES FOR AGRICULTURAL APPLICATIONS**
B17	**Bolesław Szadkowski, Anna Marzec** **FROM NATURE TO PROTECTION: MULTI-FUNCTIONAL CHITOSAN COATINGS WITH NATURAL ADDITIVES FOR ANTIMICROBIAL AND FLAME-RETARDANT COTTON TEXTILES**
B18	**Zofia Helena Bagińska, Emilia Szymańska** **BARRIER AGENT OR PENETRATION ENHANCER? – THE ROLE OF CHITOSAN IN TOPICAL FORMULATIONS**
B19	**Magdalena Gierszewska, Julia Paluszyńska, Ewa Olewnik-Kruszkowska** **EFFECT OF CHITOSAN-BASED PACKAGING FILMS WITH TEA TREE EXTRACT ON THE ANTIOXIDATIVE FEATURES OF COSMETICS DURING ACCELERATED STORAGE**
B20	**Weronika Gonciarz, Marek Brzeziński, Artur Lewandowski, Paweł Wawrzyniak, Magdalena Chmiela** **CAN *MYCOBACTERIUM BOVIS* BCG BACILLI BE A CANDIDATE FOR PREVENTING THE DEVELOPMENT OF *HELICOBACTER PYLORI* INFECTION?**
B21	**Katarzyna Struszczyk-Świta, Magdalena Gierszewska** **AN INNOVATIVE MICROWAVE-ASSISTED APPROACH FOR CHITOSAN EXTRACTION FROM THE BIOMASS OF *MUCOR CIRCINELLOIDES***
B22	**César I. Hernández Vázquez, Zbigniew Draczyński** **COMPARATIVE IMPACT OF CARBOXYLIC ACID SOLVENTS ON WET-SPUN FIBERS FROM DIFFERENT SOURCES**
B23	**Joanna Kluczka, Łukasz Wujcicki, Tomasz Mańdok** **USE OF CHITOSAN MODIFIED WITH LANTHANIDE SALTS FOR SORPTION REMOVAL OF ANIONS FROM WATER**

B24	**Marta Wasilewska, Beata Gutarowska, Anna Masek** **CHITIN FROM INSECT EXOSKELETONS AS A BIOTECHNOLOGICAL PACKAGING MATERIAL WITH ANTIBACTERIAL PROPERTIES**
B25	**Bianca-Iustina Andreica, Irina Rosca, Luminita Marin** **BIOMEDICAL APPLICATIONS OF HYDROGELS DESIGNED FROM CHITOSAN SHIFF BASE DERIVATIVES**

SESSION C ORAL PRESENTATION		
Chairman		**Prof. Olga MARCHUT-MIKOŁAJCZYK, Ph.D., D.Sc.**
C1	**12^{20}-12^{40}**	**Bianca-Iustina Andreica, Alexandru Anisiei, Irina Rosca, Luminita Marin** **NANOFIBERS BASED ON CHITOSAN/QUATERNIZED CHITOSAN SCHIFF BASES DESIGNED AS HEMOSTATIC BANDAGES**
C2	**12^{40}-13^{00}**	**Katarzyna Kresse-Walczak, Katrin Binz, Meissner Heike, Klaus Boening** ***IN VITRO* SIMULATION OF MINERALIZED BIOFILM USING CHITOSAN-BASED ARTIFICIAL CALCULUS EQUIVALENTS**
C3	**13^{00}-13^{20}**	**Magdalena Paczkowska-Walendowska, Anna Rył, Piotr Owczarz, Jakub Kwiatek, Judyta Cielecka-Piontek** **BAICALEIN-LOADED CHITOSAN FILMS: A NOVEL BIOMATERIAL FOR THE TREATMENT OF ORAL INFECTIONS**

13^{20}-14^{30}	**Lunch**
14^{30}-19^{00}	**Visiting the monuments of Łódź with a guide.** ***Łódź: From the Legacy of Izrael Poznański to Modern Times***
20^{00}-24^{00}	**Gala dinner** ***"Soplicowo"* Restaurant***

*** *"Soplicowo"* Restaurant, Łódź, Wigury Street 12a, www.soplicowo.com.pl**

September 26th 2025 – Friday

9^{00}-10^{30}		**General Assemble of the Polish Chitin Society** *(only for PTChit members)*
		SESSION D **ORAL PRESENTATION**
Chairman		**Katarzyna KRESSE-WALCZAK, Ph.D., Dr. med. dent**
D1	**10^{30}-10^{50}**	**Joanna Odrobińska-Baliś, Magdalena Procner, Kinga Krużel, Magdalena Regulska, Monika Leśkiewicz, Dorota Duraczyńska, Szczepan Zapotoczny, Władysław Lasoń, Krzysztof Szczepanowicz** **CHITOSAN NANOCAPSULES FOR ENCAPSULATION OF LIPOPHILIC NEUROPROTECTANTS: TOWARD ADVANCED CNS DRUG DELIVERY SYSTEMS**
D2	**10^{50}-11^{10}**	**Joanna Kurczewska** **CHITOSAN-BASED HYDROGEL BEADS INCORPORATING MOLECULARLY IMPRINTED POLYMERS FOR SELECTIVE ADSORPTION OF PHARMACEUTICALS**
D3	**11^{10}-11^{30}**	**Sabrina Scheele, Irina Kuznik, Lukas Benecke, Chokri Cherif** **CHITIN AND CHITOSAN FILAMENT YARNS FROM VARIOUS NATURAL SOURCES FOR MEDICAL AND TECHNICAL APPLICATIONS**
D4	**11^{30}-11^{50}**	**Daniela Ailincai, Luminita Marin** **HYDROGELS BASED ON IMINOCHITOSAN DERIVATIVES FOR BIOMEDICAL APPLICATIONS**
D5	**11^{50}-12^{10}**	**Anna Rył, Andrea Jannina Fernandez, Manlio Tassieri, Piotr Owczarz** **MAPPING THE MULTISCALE VISCOELASTIC LANDSCAPE OF CHITOSAN SOLUTIONS**
12^{10}-12^{30}		**Coffee/tea break**

		SESSION E **ORAL PRESENTATION**
Chairman		**Daniela AILINCAI, Ph.D.**
E1	**12^{30}-12^{50}**	**Izabela Myjak, Marcin Barburski, Zbigniew Draczyński, Dominik Sikorski** **MODIFICATION OF CELLULOSE-BASED TEXTILE PRODUCTS WITH CHITOSAN SALT**
E2	**12^{50}-13^{10}**	**Julia Kietlińska, Anna Marzec, Zbigniew Draczyński, Dominik Sikorski** **INVESTIGATION OF ORGANIC PLASTICIZERS AND THEIR IMPACT ON THE ELASTICITY OF CHITOSAN FILMS FOR FUNCTIONAL COATING APPLICATIONS**

E3	**13^{10}-13^{30}**	**Akshayaa Sankar, Ramyadevi Durai, Vedha Hari B Narayanan, Marek Brzeziński** **SPRAY DRIED EFAVIRENZ LOADED CHITOSAN NANOPARTICLE: A LONG-ACTING ANTI-RETROVIRAL THERAPY FOR HIV**
13^{40}-14^{00}		**Closing of the conference**
14^{00}-15^{00}		**Lunch**

Katarzyna Pieklarz
Lodz University of Technology, Faculty of Process and Environmental Engineering, Department of Environmental Engineering, Wolczanska 215 Street, 93-005 Lodz, Poland

THE NEW FACE OF CHITOSAN-BASED BIOMATERIALS FOR TISSUE ENGINEERING

One of the significant challenges of modern tissue engineering is the design of biomaterials that would not only replace damaged tissues but also enable their full regeneration without the need for further surgical or pharmacological intervention.

Currently, among biomaterials, including those based on chitosan, smart hydrogels that respond to environmental stimuli are enjoying great interest, among which, in terms of medical applications, the most attention is paid to thermosensitive systems.

In addition to the enormous interest in the application possibilities of biomaterials, there is also a noticeable increase in research undertaken in the field of nanomedicine. Of particular interest are chitosan-based composites containing nanostructured carbon materials, among which graphene and graphene oxide occupy a leading position [1].

The above trends have led to research on the development of innovative thermosensitive chitosan hydrogels, with a view to their potential use as scaffolds in tissue engineering [2,3].

These systems were prepared from chitosan lactate and chitosan chloride solutions with the use of uridine 5'-monophosphate disodium salt, which has neuroprotective and neuroregenerative effects, as the crosslinking agent. In addition, the developed hydrogels were modified by introducing a nanofiller (graphene oxide) into the polymer matrix [4].

As part of the work, the physicochemical characterisation of the obtained chitosan systems was performed and *in vitro* biocompatibility tests were conducted. Firstly, the sol-gel transition temperature of the colloidal systems was determined. The hydrogels were also analysed using FTIR spectroscopy, XRD diffraction, scanning electron microscopy (SEM), and differential scanning calorimetry (DSC). Biological studies included assessing the cytotoxicity and genotoxicity of the hydrogels against the HT-29 cell line and the BJ fibroblast line.

The conducted studies have shown that this research direction is promising, and the developed chitosan hydrogels are an attractive material for potential use as scaffolds in tissue engineering. Given the neuroprotective and neuroregenerative effects of chitosan and uridine 5'-monophosphate disodium salt, it would be worthwhile to conduct future research on the potential use of these hydrogels as a minimally invasive solution (injectable hydrogels) for the regeneration of damage within the nervous system.

Acknowledgements:
The research was funded by the Young Scientists Fund at the Faculty of Process and Environmental Engineering at the Lodz University of Technology, Poland [grant number: 501/10-34-2-7058], and the funds of the Medical University of Lodz.

References:

[1] K. Pieklarz, M. Tylman, Z. Modrzejewska, Applications of chitosan-graphene oxide nanocomposites in medical science: A review, Progress on Chemistry and Application of Chitin and its Derivatives, XXIII (2018) 5-24.
[2] K. Pieklarz, G. Galita, M. Tylman, W. Maniukiewicz, E. Kucharska, I. Majsterek, Z. Modrzejewska, Physico-Chemical Properties and Biocompatibility of Thermosensitive Chitosan Lactate and Chitosan Chloride Hydrogels Developed for Tissue Engineering Application, Journal of Functional Biomaterials, 2: 37 (2021).
[3] K. Pieklarz, J. Jenczyk, Z. Modrzejewska, P. Owczarz, S. Jurga, An Investigation of the Sol-Gel Transition of Chitosan Lactate and Chitosan Chloride Solutions via Rheological and NMR Studies, Gels, 10: 670 (2022).
[4] K. Pieklarz, G. Galita, I. Majsterek, P. Owczarz, Z. Modrzejewska, Nanoarchitectonics and Biological Properties of Nanocomposite Thermosensitive Chitosan Hydrogels Obtained with the Use of Uridine 5'-Monophosphate Disodium Salt, International Journal of Molecular Sciences, 11:5989(2024).

Session A

Irina Kuznik[1], Sabrina Scheele[1], Chokri Cherif[1], Katja Heppe[2], Moritz Gold[3], Jonas Finck[3], Axel Wähling[4], Barbara Zippel[4], Ina Turinsky[5], Mareike Gast[5]

[1] – Institute of Textile Machinery and High Performance Material Technology (ITM), TU Dresden
[2] – BioLog Heppe GmbH
[3] – madebymade GmbH
[4] – NIG Nahrungs-Ingenieurtechnik GmbH
[5] – Burg Giebichenstein Kunsthochschule Halle, University of Art and Design

INSECTMATTER: INSECT-BASED CHITIN FOR REGIONAL BIOECONOMY

Chitin is one of the most widely used biopolymers, with diverse applications and significant economic relevance. The project „insectmatter" investigated regional value chains based on insect-derived chitin from ecological and economic perspectives. The overarching goal was to establish sustainable, circular material flows using locally available biomass.

To achieve this, an interdisciplinary consortium explored the entire value chain, from raw material to product design. madebymade GmbH (Pegau, Germany) optimized the rearing of larvae and the collection of exuviae of *Hermetia illucens* by manipulating biotic and abiotic parameters. Key findings included a significant increase in chitin-rich by-products under controlled conditions (e.g. temperatures for an optimal larval exoskeleton yield), as well as the development of automated separation techniques.

BioLog Heppe GmbH (Landsberg, Germany) and NIG GmbH (Magdeburg, Germany) have developed extraction processes that yield up to 60% chitin, 30% chitosan and 4% melanin complex from insect biomass, which is on a par with or exceeds the yields obtained from conventional crustaceans. Additionally, the CO_2 footprint and material efficiency of insect chitin were benchmarked against shrimp-based counterparts, revealing promising sustainability advantages. Functional testing of chitosan demonstrated its strong flocculation potential in neutral to alkaline environments, suggesting potential applications in wastewater treatment, biogas processing, and personal care.

Specialists in pigments at NIG successfully extracted melanin from insect biomass using scalable processes that improved chemical efficiency. Melanin-derived iron pigments were also produced and characterized. At the ITM of the TU Dresden, we demonstrated that insect chitosan can be spun into monofilament and multifilament yarns for use in the textile, medical and cosmetics sectors. Additionally, coating formulations containing functionalized chitosan demonstrated potential for use in food-grade packaging.

Furthermore, BioLab and SustainLab at Burg Giebichenstein University of Art and Design (Halle, Germany) developed regionally specific material blends incorporating chitosan and agricultural residues. Prototypes such as door handles

and luminaires showcased the material's adaptability and aesthetic qualities, as well as its role in a design-driven circular bioeconomy.

The project's outcomes highlight the potential of insect-based chitosan for sustainable, regional material innovation, combining ecological impact reduction, circular economy strategies and design-led applications.

Acknowledgements:
We gratefully acknowledge the funding of the BioZ alliance project „insectmatter" by the German Federal Ministry of Education and Research (BMBF) within the framework of the WIR! – Wandel durch Innovation in der Region program, supported by Project Management Jülich (PtJ).

Katarzyna Gurzawska-Comis[1], **Salwa Suliman**[2], **Anna Mieszkowska**[3], **Bodil Jørgensen**[4], **Kamal Mustafa**[2]

[1] – *Aarhus University, Department of Dentistry and Oral Health, Section of Oral and Maxillofacial Surgery and Oral Pathology, 1610, Vennelyst Blvd. 9, 8000 Aarhus, Denmark*

[2] – *University of Bergen, Department of Clinical Dentistry, Tissue Engineering, Årstadveien 19 NO-5020 BERGEN, Norway*

[3] – *Jagielonian University, Department of Microbiology, Faculty of Biochemistry, Biophysics and Biotechnologyt, ul. Gronostajowa 7, 30-387 Kraków, Poland*

[4] – *University of Copenhagen, Department of Plant and Environment Science, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark*

SUSTAINABLE PLANT POLYSACCHARIDE-BASED BIOMATERIALS FOR BONE REGENERATION IN AGING POPULATION

The repair and treatment of large bone defects in patients with compromised bone metabolism due to ageing and medical conditions such as osteoporosis present often a clinical challenge. The aim of our study was to promote bone regeneration using sustainable plant-based biomaterials *in vitro* and *in vivo* using aging and osteoporotic rodent models.

The biomaterials were poly(l-lactide-co-ε-caprolactone) scaffolds, functionalised with Rhamnogalacturonan-I (RG-I), produced from **potato food industry waste streams**.[1] Functionalised scaffolds with RG-I (test group) and without RG-I (control group) were evaluated *in vitro* with human osteoblasts from osteoporotic patients. *In vivo* evaluation was performed using critical-size calvaria bone defect model in aging and osteoporotic rat models. Scaffolds were implanted randomly in aged and osteoporotic female Wistar rats. After 2 and 8 weeks animals were euthanised. Harvested samples were analysed for osteogenic and inflammatory markers using real-time PCR. Bone formation was evaluated radiographically and histologically. The Data was analysed using one-way ANOVA.

Osteoblasts response suggested osteogenic (upregulation *osteopontin, osteocalcin, collagen1, bone sialoprotein)* and anti-inflammatory properties (downregulation *IL-1, IL-8, TNFalpha)* on the scaffold with RG-I. The *in vivo* results in elderly and osteoporotic rat calvaria model of early bone regeneration showed increase of osteogenic markers and decrease of proinflammatory markers and *RANKL*, compared to control. In osteoporotic rat model at week 2 and 8 and in elderly rat model at week 8, the mean percentage of bone volume/tissue volume with RG-I scaffold was significantly greater than with control. The histological evaluation in both rat models revealed larger areas of new bone formation in RG-I scaffolds than in control.

In conclusion, the plant-derived nanoparticles significantly increased osteogenic and decreased pro-inflammatory response *in vitro* and *in vivo*. These

finding may have a crucial influence on bone repair process especially in elderly and osteoporotic patients.

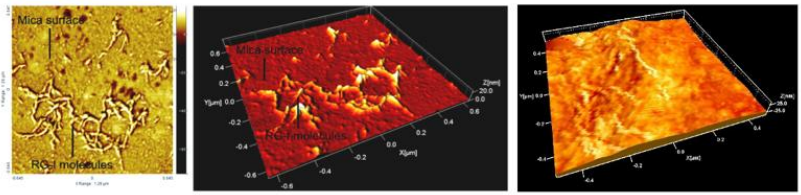

Figure 1. Atomic Force Microscopy of RG-I (Rhamnogalacturonan-I) nano-structure in 2D and 3D.

Acknowledgements:
GreenNanoBone – EU funded project

References:

[1] Hao-Chen Chang, Bodil Jørgensen, Lucy Di Silvio, Kasia Gurzawska-Comis, 3D bioprinted pectin-based hydrogel as sustainable biomaterials for musculoskeletal tissue engineering, Sustainable Materials and Technologies, Volume 38, December 2023, e00732.

Olga Marchut-Mikołajczyk, **Piotr Drożdżyński**
Lodz University of Technology, Institute of Molecular and Industrial Biotechnology, Stefanowskiego 2/22, 90-537 Lodz, Poland

NATURAL ENZYME FACTORIES: CHITOSANOLYTIC ACTIVITY IN FUNGI FROM *CHELIDONIUM MAJUS*

Endophytic fungi are increasingly recognized as promising producers of bioactive compounds, including enzymes with industrial and agricultural relevance. In this study, we explored the chitosanolytic potential of fungal endophytes isolated from the stems of *Chelidonium majus* L., a medicinal plant known for its rich phytochemistry. Two fungal strains, designated R and Z, were cultured on Czapek-Dox medium. Microscopic identification revealed that strain Z belongs to the genus *Aspergillus*. Both strains were screened for chitosanolytic enzyme production in media supplemented with chitosan, under both surface and submerged culture conditions. Intracellular chitosanolytic activity was observed in both isolates, with strain Z showing the highest activity, reaching 656 μmol/(min·g). These results highlight *C. majus* as a valuable ecological niche for enzyme-producing endophytes and provide a basis for further development of novel chitosan-degrading biocatalysts from natural fungal sources.

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[2] Jakuubi MM, Munusamy M, Liang ZX, Ng SB; (2021) Fungal Endophytes: A Promising Frontier for Discovery of Novel Bioactive Compounds. J Fungi (Basel) 7(10), 786. Doi:10.3390/jof7100786
[3] Drożdżyński P, Rutkowska N, Rodziewicz M, Marchut-Mikołajczyk O; (2024) 281 Bioactive Compounds Produced by Endophytic Bacteria and Their Plant Hosts—An 282 Insight into the World of Chosen Herbaceous Ruderal Plants in Central Europe. 283 Molecules 29, 4456. Doi:10.3390/molecules29184456.

Piotr Drożdżyński, **Olga Marchut-Mikołajczyk**
Lodz University of Technology, Institute of Molecular and Industrial Biotechnology, Stefanowskiego 2/22, 90-537 Lodz, Poland

A DUAL-ACTION BIOPREPARATION: ENDOPHYTIC BIOSURFACTANTS AND CHITOSAN FOR CROP STIMULATION

Endophytic microorganisms are increasingly recognized as valuable allies in sustainable agriculture, enhancing plant growth and resilience. In this study, we present a novel dual-action biopreparation combining a biosurfactant-producing endophyte (*Bacillus pumilus* 2A), isolated from *Chelidonium majus* L., with chitosan dissolved in citric acid. The formulation was tested at concentrations ranging from 0.1% to 0.4% on five crop species: corn (*Zea mays*), rye (*Secale cereale*), buckwheat (*Fagopyrum esculentum*), oats (*Avena sativa*), and barley (*Hordeum vulgare*). The 0.2% formulation showed the most pronounced effect, particularly in rye and buckwheat, where root and shoot biomass increased by up to 316% compared to untreated controls.

Although the acidified chitosan component influenced soil pH, potentially modulating plant response, the combined action of biosurfactant and chitosan proved significantly effective. These findings demonstrate the promising potential of endophyte-derived biosurfactant–chitosan formulations as eco-friendly biostimulants, capable of supporting crop productivity even under environmental stress conditions.

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Session B

B1

Katarzyna Małolepsza-Jarmołowska[1], **Hanna Bazan**[2]

[1] – *Wroclaw Medical University The „Silesian Piasts" memorial, Faculty of Pharmacy, Department of Drug Form Technology, Borowska 211A Street, 50-556 Wrocław, Poland*

[2] – *Wroclaw Medical University The „Silesian Piasts" memorial, Faculty of Medicine, Mikulicza-Radeckiego 5 Street, 50-345 Wrocław, Poland*

STUDY OF THE EFFECT OF POLYVINYLPYROLIDONE K-15 ON THE PROPERTIES OF CHITOSAN GELS PREVENTING THE EFFECTS OF REFLUX

Gastroesophageal reflux disease (GERD) is a condition in which the abnormal reflux of stomach contents into the esophagus causes bothersome symptoms or complications. It is a chronić disease. Typical symptoms of GERD include heartburn and a sensation of stomach contents flowing back into the esophagus, which worsen when lying on your back or bending over, especially after a large or fatty meal. Treatment includes lifestyle modyfications and medications, primarily those that inhibit hydrochloric acid secretion. Preparations that protect the esophageal mucosa are also used. Their effect is usually short-lived due to the rapid flushing of the preparation from the mucosal surface [5].

The aim of the work was to investigate the influence of polyvinylpyrrolidone K-15 on the properties of chitosan-containing gels.

The effect of chitosan on the properties of gels was investigated. The formulations were prepared with various pH and rheological properties. Based on the obtained research results, the gels were enriched with the addition of polyvinylpyrrolidone K-15. The introduction of this component allowed obtaining new beneficial properties of the tested gels. The obtained results of experimental studies have shown that it is possible to produce a preparation with optimal pharmaceutical and application properties. Gels show the adhesion and the ability to cover the surface of the apparatus simulating the conditions in the esophagus. Due to their adhesive properties, the tested gels should stay on the esophageal mucosa for a long time and protect it against the adverse effects of gastric or bile contents. The wide range of pH of the investigated gels enables selection of a preparation with optimal pH for the esophagus. Additionally, gels with alkaline pH could neutralize acids. Presented assumptions and investigations *in vitro* require verification *in vivo*, what is the aim of subsequent studies.

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B2

Katarzyna Małolepsza-Jarmołowska [1], **Hanna Bazan** [2]

[1] – *Wroclaw Medical University The „Silesian Piasts" memorial, Faculty of Pharmacy, Department of Drug Form Technology, Borowska 211A Street, 50-556 Wrocław, Poland*

[2] – *Wroclaw Medical University The „Silesian Piasts" memorial, Faculty of Medicine, Mikulicza-Radeckiego 5 Street, 50-345 Wrocław, Poland*

CHITOSAN GELS PROTECTING THE ESOPHAGEAL MUCOSA CONTAINING A THERMOSENSITIVE POLYMER IN THE PRESENCE OF HYDROPHILIZING SUBSTANCES

Improper treatment of gastroesophageal reflux disease (GERD) or its absence results in long-term exposure of the delicate mucosa of the esophagus to gastric juices. Consequently, inflammation develops continuously, which can lead to numerous, serious complications. Common complications in patients with GERD include: esophageal stricture, Barrett's esophagus, erosions, ulcers and bleeding, perforated ulcer, esophageal cancer. Proper protection of the esophageal mucosa plays an important role in the proper treatment of this chronic disease [5].

The aim of the study was to investigate the effect of a thermosensitive polymer in the presence of hydrophilizing substances on the adhesive properties of gels containing chitosan.

Gels containing chitosan have prepared to protect the esophageal mucosa from the irritating effects of gastric contents. To increase viscosity of the gels and their adhesion to the surface for the protection of the esophageal mucosa, a thermosensitive polymer, poloxamer 407, was used. Due to the increase in pH of chitosan gels to which poloxamer 407 was added, further attempts were made to modify the composition of the gels. In order to obtain the possibility of regulating the pH of the gels, due to their therapeutic purpose, the gels were enriched with hydrophilizing substances such as glycerol, 1,2-propylene glycol and polyoxyethylene glycol 200. On the basis of the tests, the dynamic viscosity of gels was determined. Gels show the adhesion and the ability to cover the surface of the apparatus simulating the conditions in the esophagus. On the basis of performed investigations *in vitro*, it may be assumed that the gels will remain at the site of application in the form of a layer coating the mucous membrane of the oesophagus and protecting it against an irritating effect of gastric content backflow. Thanks to the addition of hydrofilizing substances, an optimal pH range was achieved. The glycerol, 1,2-propylene glycol and polyoxyethylene glycol 200 added to the gels allow for the differentiation of pH depending on the type of reflux. The investigated gels, thanks to their adhesive properties, should remain on the mucous membrane of the oesophagus for a prolonged time and protect it against the unfavourable effect of gastric content. Laboratory tests require clinical confirmation.

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B3

Anna Marzec[1], **Bolesław Szadkowski**[1], **Zbigniew Draczyński**[2], **Dominik Sikorski**[2]

[1] – *Lodz University of Technology, Chemistry Faculty, Institute of Polymer and Dye Technology, 16 Stefanowskiego Street, 90-537 Lodz, Poland*

[2] – *Lodz University of Technology, Faculty of Material Technologies and Textile Design, Institute of Textiles, 116 Zeromskiego Street, 90-543 Lodz, Poland*

SUSTAINABLE BIOACTIVE FORMULATION FOR ECO-FRIENDLY COTTON: ENHANCING ANTIMICROBIAL EFFICACY AND FIRE RESISTANCE

The aim of this study was to develop a bioactive coating for the fabrication of biodegradable and environmentally sustainable textiles exhibiting antiviral, antibacterial, and antifungal properties. The antimicrobial performance of the functionalized fabrics was evaluated against *Staphylococcus aureus*, *Escherichia coli*, *Aspergillus niger*, and *Candida albicans*, while antiviral efficacy was assessed using the human influenza A virus (H1N1) as a model pathogen. The morphological characteristics of the modified cotton substrates were examined via optical microscopy and scanning electron microscopy (SEM). Their pH-responsive behavior was analyzed spectrophotometrically. Biodegradability was assessed under standardized composting conditions, and flammability was evaluated using micro-combustion calorimetry (MCC).

The results demonstrated that the application of the bioactive coating imparted pronounced antiviral, antibacterial, and antifungal activity to the treated textiles. MCC analysis revealed improved flame-retardant performance of the coated samples, as evidenced by decreased heat release rate (HRR), total heat release (THR), and fire growth rate (FIGRA) compared to untreated cotton. These findings suggest that the proposed bioactive formulation represents a promising approach for the development of multifunctional, eco-friendly textile materials.

B4

Renata Czechowska-Biskup, Klaudia Jakubowska, Malwina Olejniczak, Bożena Rokita, Piotr Ulański

Institute of Applied Radiation Chemistry, Faculty of Chemistry, Lodz University of Technology, Wroblewskiego 15, 93-590 Lodz, Poland

SONOCHEMICAL SYNTHESIS OF CHITOSAN-STABILIZED SILVER NANOPARTICLES

Silver nanoparticles (AgNPs) are increasingly employed in diverse fields, particularly in medicine, electronics, and advanced materials technologies, due to their unique optical, electrical, and catalytic properties [1]. Their nanoscale dimensions, high surface area-to-volume ratio, enhanced reactivity with biological systems, and long-term physicochemical stability make them especially effective as antimicrobial agents.

Growing scientific interest in AgNPs has driven continuous improvements in their synthesis methods and physicochemical quality. Most commonly, AgNPs are via chemical reduction of silver salts such as silver nitrate ($AgNO_3$) or silver sulfate (Ag_2SO_4), using various reducing agents. These include inorganic compounds like sodium borohydride and hydrazine hydrate, as well as organic reducing agents such as ascorbic acid, citrate, and polyols. The choice of reducing agent significantly influences the size, shape, and stability of the resulting nanoparticles. However, chemical methods often leave impurities that are difficult to remove and may affect nanoparticle purity.

In contrast, sonochemical synthesis, which relies on ultrasonic action, offers a cleaner and more environmentally friendly alternative [2]. This technique induces cavitation phenomena that can drive redox reactions, including reduction of metal ions, without the need for chemical reducing agents. To prevent aggregation caused by the high surface energy of metal nanoparticles during synthesis, stabilizers are typically employed. Among them, chitosan—a natural polysaccharide—is widely used due to its ability to enhance colloidal stability through interactions involving amino groups.

The aim of this study was to optimize reaction parameters for the sonochemical synthesis of chitosan-stabilized silver nanoparticles. Silver nitrate was used as the precursor, and chitosan of medium molecular weight served as the stabilizing agent. The synthesized nanoparticles were characterized using UV-Vis spectroscopy, dynamic light scattering (DLS), and transmission electron microscopy (TEM) to evaluate their size, morphology, and stability.

Our results show that in sonication methods, in proposed systems at pH 3 and 4 can formulated silver nanoparticles. Probably obtaining nanoparticles constitute of the silver core surrounding by chitosan particles. Spectrophotometric analysis revealed a pronounced surface plasmon resonance (SPR) band in the range of 410–420 nm, indicative of the characteristic optical response of AgNPs in the visible spectrum. The resulting dispersions exhibited a intense yellow coloration,

corresponding to the presence of nanoparticles with a hydrodynamic diameter of approximately 410 nm, as determined via DLS. Zeta potential measurements yielded values below –30 mV, suggesting high electrostatic stabilization of the colloidal system. The physicochemical stability of the synthesized nanoparticles was confirmed over a 30-day observation period under ambient conditions, with no significant aggregation or precipitation detected.

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B5

Aleksandra Dziopa, Oskar Zimak-Krótkopad, Judyta Cielecka-Piontek

Insitute of Natural Fibers and Medical Plants, Departament of Pharmacology and Phytochemistry, Wojska Polskiego 71b 60-630 Poznan, Poland

EXTRACTION AND CHARACTERIZATION OF CHITOSAN FROM DIFFERENT SILKWORM SPECIES

Chitin ranks among the most abundant natural polymers, second only to cellulose [1]. While marine organisms are the primary source, various insects – including beetles, grasshoppers, silkworms and mealworms-also contain significant amounts of chitin. Nonetheless, it is chitosan, a deacylated derivative of chitin, that sees broader industrial use. This is due to its solubility in acidic environments and its ability to be more easily processed into various functional forms. It is especially valued for its antimicrobial, antioxidant, and even anticancer properties [2]. However, the characteristics of chitosan can vary, depending on the methods used for its production. Therefore, identifying new alternative sources and gaining a better understanding of both chitin and chitosan is essential. Silkworm pupae are rich in carbohydrates, proteins, and lipids. If not used as animal feed, they can serve as a potential source of valuable biopolymers for industrial and scientific applications. Notably, the chitin content in silkworms may vary, depending on their breed and sex, which should be taken into account during material selection. Chitosan extracted from silkworm pupae shows physicochemical properties and biological effects similar to those of commercially available chitosan. Moreover, chitosan derived from silkworm pupae has shown strong antibacterial and antifungal activity as well as excellent cytocompatibility, making it valuable material for biomedical, pharmaceutical and food applications.[3]. In biomedical applications, chitosan has been successfully used in the development of medical devices such as biodegradable sponges and hydrogels, particularly for wound healing and tissue engineering purposes [4]. In pharmaceutical fields, chitosan is applied in solid formulations including mucoadhesive tablets and film coatings, where it serves as a binder, disintegrant and controlled-release agent [5]. In food industry, chitosan is explored as a biodegradable packaging material offering antimicrobial protection and reducing environmental impact [6]. These findings highlight the potential of silkworm chitosan as a valuable material and justify further investigation into its properties and applications.

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B6

Urszula Filipkowska, Tomasz Jóźwiak

University of Warmia and Mazury in Olsztyn , Department of Envirinmental Engineering, Warszawska Street 117a,10-720 Olsztyn Poland

EFFICIENCY OF THE REACTIVE BLACK 5 DYE REMOVAL IN AN AIR-LIFT REACTOR AND IN A COLUMN REACTOR

Various industries, e.g. the textile, dyeing, pulp and paper, food, leather, pharmaceutical and cosmetics industries, are characterised by a high demand for water in their production processes and produce large quantities of coloured wastewater. It is estimated that around 8000 different synthetic dyes are currently produced. The global market for dyes and pigments was estimated at USD 33.2 billion in 2019 and is expected to reach USD 49.1 billion by 2027[1,2]. Every year, around 70 million tonnes of dyes are produced in the textile industry worldwide, and due to the still imperfect dyeing processes, up to 50% of dyes are discharged into the environment in the form of process wastewater [3,4].

The paper compares the efficiency of the sorption process of the anionic dye Reactive Black 5 (RB5), which is popular in the textile industry, on chitosan. The sorption process was carried out in an air-lift reactor and in a column reactor.

The sorption of the Reactive Black 5 dye from an aqueous solution was studied in two variants: using an unmodified chitosan sorbent and a chitosan sorbent modified with pentasodium tripolyphosphate. They allowed to determine the best conditions for the adsorption of coloured impurities from aqueous solutions. Under uniform flow conditions (50 cm^3/h) in the air-lift reactor and in the column reactor, the maximum adsorption capacities of the sorbents and the operating parameters of the tested reactors were determined. The RB5 adsorption process was the most efficient in the column reactor when using a sorbent in the form of non-crosslinked chitosan. The maximum adsorption capacity for the non-crosslinked chitosan sorbent was 941.6 mg/g in the air-lift reactor and 1249.0 mg/g in the column reactor. The maximum adsorption capacity for the chitosan sorbent cross-linked with pentasodium tripolyphosphate was 417.3 mg/g in the air-lift reactor and 382.1 mg/g in the column reactor.

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B7

Małgorzata Gnus

Łukasiewicz Research Network – Institute of Polymer Materials, M. Skłodowskiej-Curie 55 Street, 87-100 Toruń, Poland

MIXED MATRIX CHITOSAN MEMBRANES – INFLUENCE OF METAL OXIDE PARTICLES ON WATER AND ETHANOL TRANSPORT PROPERTIES IN VAPOUR PERMEATION PROCESS

Nowadays, the techniques used to solutions purification from undesirable components, especially membrane methods are widely recognized. However, despite on a wide range of polymers, the possibility of using them as membrane, without prior modyfication, is quite limited.

Chitosan as a material with features like good film-forming properties, good chemical resistance or high hydrophilicity also needed additional modification to improve their separation properties in dehydration process. An useful strategy for the improving separation efficiency of polymeric membranes is formation of hybrid materials by input inorganic materials, typically oxides into the polymer matrix.

The aim of this work was mixed matrix chitosan membranes's comparison of transport properties in vapour permeation process. For this purpose series of membranes filled with different amount of nickel, cobalt, manganese and copper metal oxides were used. Transport properties of prepared membranes were tested for water, ethanol and ethanol-water mixture.

The results of the research showed that the kind of used metal oxide as well as their amount into polymer matrix influence on their transport properties. Moreover transport properties obtained for pure solvents could not predict membrane properties for their mixture.

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B8

Barbara Hawrylak-Nowak[1], Stawomir Dresler[2,3], Jan Sawicki[2], Renata Matraszek-Gawron[1], Maria Stasińska-Jakubas[1], Katarzyna Rubinowska[1], Weronika Woch[1]

[1] – *University of Life Sciences in Lublin, Department of Botany and Plant Physiology, Akademicka 15, 20-950 Lublin, Poland*

[2] – *Medical University of Lublin, Department of Analytical Chemistry, Chodźki 4a, 20-093 Lublin, Poland*

[3] – *Maria Curie-Skłodowska University, Department of Plant Physiology and Biophysics, Akademicka 19 Lublin, Poland*

A Comparative Evaluation of the Ability of Two Chemical Forms of Chitosan to Alleviate Salinity-Induced Stress in *Cucumis sativus* L.

Soil salinity is a major abiotic stressor that limits crop productivity worldwide. High concentrations of soluble salts can disrupt a plant's water relations, inducing ionic and osmotic stress and leading to oxidative damage. As salinized agricultural land expands, there is an urgent need for sustainable strategies to enhance plant stress resistance [1]. Chitosan, a natural biopolymer derived from chitin, has emerged as a promising biostimulant capable of modulating plant defense responses against both pathogens and abiotic stress. Its efficacy is influenced by chemical properties, such as the degree of deacetylation, molecular weight and formulation type, all of which affect solubility and interaction with plant tissues [2,3].

In this study, we investigated the effects of two chemical forms of chitosan on cucumber (*Cucumis sativus* L.) stressed by 50 mM NaCl, using a controlled hydroponic system. Our objectives were to determine whether the form of chitosan alters its bioactivity and to identify the associated physiological and biochemical responses to stress mitigation. We used chitosan from shrimp shells (500 mg/L) in two forms: chitosan lactate (ChL; deacetylation degree of 80–95%) and conventional chitosan (Chit; deacetylation degree of ≥75%).

Our results suggest that the two forms of chitosan differ in their ability to alleviate salinity-induced damage, likely due to differences in physicochemical properties that affect plant signaling. Chit was more effective than ChL in reducing the negative impact of salinity, increasing shoot and root biomass, and leaf area. The beneficial effects of chitosan were found to be associated with its ability to stimulate the biosynthesis of organic acids, particularly malic acid and alpha-ketoglutaric acid, in leaves. Adding chitosan to the saline substrate also modified the levels of certain macro- and micronutrients in plants without significantly affecting the K/Na ratio. Furthermore, both forms of chitosan were found to significantly stimulate the accumulation of free proline in cucumber leaves, whether used individually or under salt stress. These findings contribute to the

development of tailored biostimulant strategies for enhancing crop resilience under saline conditions.

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B9

Karolina Rolińska[1], Ewelina Jakubowska[1], Katarzyna Łęczycka-Wilk[1], Małgorzata Żmieńko[1], Szymon Mania[2], Adrianna Banach-Kopeć[2]

[1] – *Łukasiewicz Research Network – Industrial Chemistry Institute, 8 Rydygiera Str., 01-793 Warsaw, Poland*

[2] – *Gdańsk University of Technology, Department of Chemistry, Technology and Biotechnology of Food, Faculty of Chemistry, Advanced Materials Center, G. Narutowicza 11/12 Str., 80-233 Gdansk, Poland*

BIOACTIVE CHITOSAN FILMS WITH DEEP EUTECTIC SOLVENTS AND FRUIT WASTE EXTRACTS FOR IMPROVED FOOD PACKAGING PROPERTIES

The development of sustainable and functional food packaging is crucial to addressing both environmental and shelf-life challenges. Recent advances in bio-based packaging have highlighted chitosan as a promising material due to its inherent antimicrobial activity, film-forming ability, and biodegradability [1]. Furthermore, the incorporation of natural additives such as deep eutectic solvents (DES) and plant-derived polyphenols has been shown to improve flexibility, barrier properties, and microbial resistance in biopolymer films [2].

In this study, chitosan-based films were enhanced with DES and bioactive fruit peel extracts (Ext) to improve mechanical, barrier, and antimicrobial properties. The resulting Ch/DES/Ext films exhibited strong antibacterial and antifungal activity against E. coli, S. aureus, and C. albicans, and effectively suppressed mold growth on bread. Mechanical analysis revealed a significant improvement in elongation at break, increasing by up to 142% in Ch/DES/Ext films compared to 4–8% for Ch/Ext films. Furthermore, the incorporation of Ext into Ch/DES matrices lowered water vapor transmission rates from over 15 to 5–10 $g \cdot m^{-2} \cdot h^{-1}$, enhancing barrier performance. SEM imaging confirmed a uniform, dense microstructure. These results highlight the potential of combining natural extracts and DES in chitosan matrices to create biodegradable, active packaging solutions that extend food shelf life and reduce waste.

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B10

Agata Krakowska[1,2], Joanna Zontek-Wilkowska[3], Dominik Műller[1], Żaneta Binert-Kusztal[2]

[1] – *AGH University of Krakow, Department of Analytical Chemistry and Biochemistry, Al. Mickiewicza 30, 30-059 Krakow, Poland*

[2] – *Jagiellonian University Medical College, Department of Inorganic Chemistry and Pharmaceutical Analytics, 9 Medyczna Street, 30-688 Krakow, Poland*

[3] – *Jagiellonian University Medical College, Doctoral School of Medical and Health Science, Department of Inorganic Chemistry and Pharmaceutical Analytics, 9 Medyczna Street, 30-688 Krakow, Poland*

PERSONALIZED HYDROGEL DRESSING DOPED WITH BIOACTIVE SUBSTANCES - DERIVED FROM BIOMASS IN VITRO CULTURES

Creating new strategies in the treatment of difficult-to-heal wounds is still a big challenge. Developing dressings that meet all the conditions included in the acronym TIME (Tissue, Inflamation, Moisture, Edge) is extremely difficult to implement. Despite the various types of dressings available on the market, pressure wounds and diabetic foot syndrome are still a challenge. It is worth emphasizing that the risk of ulceration during the entire life of a diabetic patient is 12-25%, and the probability of amputation in patients with diabetes is 30-40 times higher than in people without diabetes [1]. Moreover, wound healing in diabetics is impaired. Therefore, the search for medicinal products of natural origin that would contribute to improving the patient's health is important not only from a socio-economic point of view, but also from a clinical one. In the presented work, research was conducted on the design of a personalized hydrogel dressing with the addition of natural bioactive substances: chitin obtained from biotechnological *in vitro* cultures of the *Pleurotus* spp. genus. The extracted substances are particularly important in the wound healing process due to their properties, including anti-inflammatory, stimulating cell proliferation and migration [1,2]. As part of the work, the obtained extracts were subjected to qualitative and quantitative analysis. The antimicrobial potential against the most common bacterial strains in the wound bed, including *Staphylococus aureus*, was determined. In addition, the physicochemical properties of the developed solution were determined: the degree of absorbability above 60% and mechanical strength.

Based on the promising results obtained, it was concluded that the developed biomaterial based on natural bioactive substances derived from biomass from *in vitro* cultures can significantly improve the efficiency and comfort of treatment of patients with skin problems, with particular emphasis on diabetic patients.

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B11

Joanna Zontek-Wilkowska[1] Agata Krakowska[2,3], Dominik Műller[3], Przemysław Dorożyński[2]

[1] – *Jagiellonian University Medical College, Doctoral School of Medical and Health Science, Department of Inorganic Chemistry and Pharmaceutical Analytics, 9 Medyczna Street, 30-688 Krakow, Poland*

[2] – *Jagiellonian University Medical College, Department of Inorganic Chemistry and Pharmaceutical Analytics, 9 Medyczna Street, 30-688 Krakow, Poland*

[3] – *AGH University of Krakow, Department of Analytical Chemistry and Biochemistry, Al. Mickiewicza 30, 30-059 Krakow, Poland*

USE OF EXTRACTED POLYSACCHARIDES FROM PLEUROTUS SPP. BIOMASS TO OBTAIN BIOACTIVE LAYERS

Polysaccharides extracted from Pleurotus spp. biomass represent a promising source of bioactive compounds with diverse functional properties. Recent advances in extraction techniques, including aqueous two-phase systems, enzymatic-ultrasonic methods, and steam explosion, have enabled the efficient isolation of high-purity polysaccharides such as β-glucans, mannose, and glucuronic acid derivatives [1-2] .These polysaccharides exhibit significant antioxidant, immunomodulatory, and antimicrobial properties, making them ideal candidates for the development of bioactive coatings for applications in the food, pharmaceutical, and biomedical industries. By incorporating Pleurotus-derived polysaccharides into layered materials, it is possible to create functional coatings and films that extend shelf life, benefit health, and provide a biodegradable alternative to synthetic polymers. The physicochemical integrity and bioactivity of these polysaccharides are preserved through optimized extraction and purification processes, facilitating their integration into innovative bioactive layers. This approach leverages the sustainable utilization of fungal biomass, contributing to a circular bioeconomy strategy and increasing the potential applications of fungal polysaccharides in advanced materials science. In this work, the polysaccharide compounds were extracted. This work summarizes key issues regarding the extraction methods, bioactivity, and applications of Pleurotus polysaccharides as bioactive layered materials on cellulose substrates.

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B12

Dominik Műller[1], Beata Paczosa-Bator[1], Joanna Zontek-Wilkowska[2], Bożena Muszyńska[3], Agata Krakowska[1,4]

[1] – *AGH University of Krakow, Department of Analytical Chemistry and Biochemistry, Al. Mickiewicza 30, 30-059 Krakow, Poland*

[2] – *Jagiellonian University Medical College, Doctoral School of Medical and Health Science, Department of Inorganic Chemistry and Pharmaceutical Analytics, 9 Medyczna Street, 30-688 Krakow, Poland*

[3] – *Jagiellonian University Medical College, Department Of Medical Plant And Mushroom Biotechnology, 9 Medyczna Street, 30-688 Krakow, Poland*

[4] – *Jagiellonian University Medical College, Department of Inorganic Chemistry and Pharmaceutical Analytics, 9 Medyczna Street, 30-688 Krakow, Poland*

EFFECTIVE CHEMICAL METHOD OF CHITOSAN EXTRACTION FROM IN VITRO CULTURES OF LENTINULA EDODES

Lentinula edodes (commonly known as the shiitake mushroom) is one of the most popular species of mushrooms, particularly well-known in Asian countries where it's recognized for its potential health-promoting, nutritional, and medicinal properties [1]. This species contains polysaccharides (including beta-glucans, which influence the human immune system), and *lentinan* is one of the most important polysaccharides (along with chitosan) that exhibit immunostimulatory, anticancer, and antiviral properties. Additionally, this species is rich in various polyphenols, flavonoids, amino acids, ergosterol, as well as sterols, lipids, and vitamins (such as vitamins B, D_2, and folic acid) [2].

Due to its above-mentioned health-promoting properties and a relatively high chitosan content (approx. 5% of dry mass), the presented study aimed to extract chitosan from biomass derived from *in vitro* cultures. For this purpose, the biomass obtained from optimized liquid media enriched with inorganic magnesium and zinc salts was lyophilized and subjected to a chemical extraction [3].

In the first step, the biomass underwent demineralization using hydrochloric acid (1M, 30°C, 2 hours), after which the resulting intermediate product was thoroughly filtered, washed with redistilled water, and dried at room temperature. The intermediate product was then deproteinized using sodium hydroxide (1M, 90°C, 2 hours). In this way, chitin was obtained, which was also filtered, washed with redistilled water, and dried at room temperature. In the final step, the obtained chitin was deacetylated using sodium hydroxide (50%, 100°C, 6 hours). After deacetylation, the pH of the solution was adjusted to approximately 7 by adding sodium acetate (10%). The resulting chitosan was dried to obtain a solid residue. This residue was then subjected to physicochemical analysis.

Chitosan obtained from *in vitro* cultures, in comparison to chitosan derived from marine waste, exhibits excellent material properties, including

increased surface area and thermostability (as demonstrated by DSC and TG analysis). Additionally, the material produced under controlled biotechnological conditions demonstrates reproducibility, consistency of composition, and stability, making it a promising candidate for use in wound treatment therapy as a potential dressing material.

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B13

Jacek Nowaczyk[1], Magdalena Gierszewska[1], Ewelina Jakubowska[2]

[1] – *Nicolaus Copernicus University in Torun, Faculty of Chemistry, Department of Physical Chemistry and Physicochemistry of Polymers, 7 Gagarina Street, 87-100 Torun, Poland*

[2] – *Łukasiewicz Research Network – Industrial Chemistry Institute, 8 Rydygiera Street, 01-793 Warsaw, Poland*

THE STUDY OF CHITOSAN BETAINE-CYTRIC ACID COMPLEX INTERMOLECULAR INTERACTIONS USING DFT

Density Functional Theory (DFT) is a widely used computational method for modeling intermolecular interactions in molecular systems and assessing their energetic properties. Chitosan has been analyzed using DFT to evaluate the strength of interchain interactions with crosslinking agents [1], investigate its interactions with metal complexes [2], and assess the affinity of polymer biomolecules [3].

In this study, the authors computed the energetic properties of a molecular model representing the intermolecular interactions between two adjacent chitosan chains at varying distances in a vacuum and in the presence of different substances. This section of the study considered water molecules, water as a continuous medium (PCM model), water and acetic acid molecules, and the betaine–citric acid complex. The latter, classified as a deep eutectic solvent (DES), consists of citric acid, which independently serves as an effective crosslinking agent for chitosan.

By comparing the binding energy of two chitosan chain fragments at their energy minimum, alongside similar systems incorporating different substances, this study provides critical insights into the strength of native chitosan interactions as a function of distance. It further examines the disruptive or reinforcing effects introduced by additives, as well as the potential for competitive binding, particularly in the context of DES based on citric acid.

Understanding the variations in binding energy enables the prediction of material properties such as solubility, gelation, and aggregation. Reduced interchain energy suggests increased flexibility and dispersion, whereas heightened energy may indicate structural stiffening or crosslinked network formation.

Beyond its fundamental insights into molecular interactions, this study has broader implications for sustainable packaging innovation. Chitosan-based materials, particularly those enhanced by deep eutectic solvents, offer promising alternatives to conventional plastic packaging. Their biodegradability, renewability, and ability to support circular economy principles—such as resource efficiency and waste reduction—make them a compelling option for future applications. By understanding the binding mechanisms within these materials, researchers can refine chitosan formulations to optimize durability, recyclability,

and environmental compatibility, contributing to the development of greener packaging solutions that align with global sustainability goals.

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B14

Katarzyna Pieklarz, **Zofia Modrzejewska**

Lodz University of Technology, Faculty of Process and Environmental Engineering, Department of Environmental Engineering, Wolczanska 215 Street, 93-005 Lodz, Poland

CHITOSAN BIOMATERIALS CONTAINING SALT OF PYRIMIDINE NUCLEOTIDE – PHYSICOCHEMICAL ASSESSMENT AND *IN VITRO* BIOCOMPATIBILITY ANALYSIS

Despite the significant development of research conducted in the field of regeneration of damaged tissues, this issue still poses a huge challenge for modern medicine.

For this reason, a new paradigm has emerged, which is an alternative to conventional treatment methods, called tissue engineering. This field combines issues from many sciences, such as: materials engineering, biotechnology, molecular biology, chemistry or biochemistry [1, 2]. The aim of this approach is to regenerate the patient's own tissues using three-dimensional, porous scaffolds that enable cell cultures [3]. Thanks to their structure, these solutions reflect the conditions in the human body, contributing to better therapy results [1, 2].

A special group of biomaterials used in tissue engineering are hydrogels, which are polymeric materials that swell in contact with water, but due to their chemically or physically cross-linked structure, they do not dissolve in it [3, 4]. Moreover, relatively high water content, softness and plasticity make hydrogels exhibit similar physical properties to living tissues.

The aim of this study was to prepare a new generation of thermosensitive chitosan hydrogels and to make a preliminary assessment of their physicochemical properties and *in vitro* biocompatibility.

These systems were obtained from chitosan lactate and chitosan chloride solutions with the use of a salt of pyrimidine nucleotide – cytidine 5'-monophosphate disodium salt – as the cross-linking agent. This substance plays many key roles in the human body. It has a neuroregulatory effect in physiological and pathological processes, has analgesic effects, supports neuroregeneration (growth of axons and myelin sheath), and stimulates protein synthesis and proliferation of Schwann cells [5, 6].

The obtained chitosan hydrogels were characterised using FTIR spectroscopy and differential scanning calorimetry (DSC). In turn, the biological studies included the evaluation of the cytotoxicity (resazurin assay) and genotoxicity (alkaline version of the comet assay) of the developed biomaterials against human colon adenocarcinoma cell line (HT-29 cell line).

The conducted research allowed to conclude that the hydrogels containing cytidine 5'-monophosphate disodium salt are an attractive material for potential use as scaffolds for the regeneration of damaged tissues.

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B15

Maria Wiśniewska-Wrona[1], Monika Sikora[1], Anna Wojtala[2], Marek Warzała[2] Klaudia Piekarska[1], Konrad Sulak[1], Dominik Borkowski[1], Wiesław Adamiec[1], Dorota Stańczyk[2]

[1] – *Lukasiewicz Research Network - Lodz Institute of Technology, M. Skłodowskiej-Curie St. 19/27, 90-570 Łódź, Poland*

[2] – *Lukasiewicz Research Network- Institute of Heavy Organic Synthesis „Blachownia", Energetyków St. 9, 47-225 Kędzierzyn- Koźle, Poland*

OBTAINING VARIOUS FUNCTIONAL FORMS FROM PLASTICIZED CHITOSAN BY EXTRUSION TECHNIQUE

Many years of research into the production of chitosan derivatives with improved thermal stability are driven by the current global trend of gradually replacing polymers derived from petrochemical raw materials with biopolymers derived from renewable sources. The largest group of naturally synthesized polymers are polysaccharides, including cellulose, chitin, chitosan, and starch.

A significant advantage of synthetic polymers derived from petroleum from a processing perspective is their thermoplasticity, which enables the easy production of various functional forms from polymer macromolecules using the melting method. Due to chitosan's decomposition temperature is lower than its melting point, its use in some industries, for example, as a bone fixative agent or food packaging material, is limited [1]. Physicochemical modification of polysaccharides enables their plasticization during extrusion.

In order to plasticize chitosan and increase the scale of its processing using extrusion techniques, research was carried out on the synthesis of appropriate biomodifiers based on natural raw materials. These modifiers were synthesized from available components, primarily from renewable sources. The chitosan used in our research exhibits high chemical reactivity and biological activity due to the presence of protonated amine groups at the C-2 position and primary and secondary hydroxyl groups at the C-3 and C-6 positions. Important physicochemical parameters that significantly influence its biological activity, chemical purity, and the value of parameters related to the technological usefulness of this polymer are the average molar mass and the degree of deacetylation.

This paper presents research results related to the production of plasticized chitosan in the form of a film and strand. The extrusion process parameters for selected chitosan/biomodifier polymer blends were selected. For the produced and selected forms of plasticized chitosan, the surface structure was assessed using a scanning electron microscope (SEM), and the physicomechanical properties, microbiological purity, and biological activity were assessed [2-4].

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B16

Monika Bil, **Wiktoria Luba**, **Bartłomiej Bukryj**, **Wiktoria Pietraszuk**, **Maciej J. Bernacki, Artem Kuchalenko**, **Tomasz Ciamulski**

FibriTech Sp z o.o., Cyklamenów 1, 04-798 Warsaw, Poland

3D Structured Cellulose Pads Functionalised with various polysaccharides for agricultural applications

Sustainable composites based on cellulose and other natural polysaccharides are gaining significant interest due to their exceptional environmental and functional benefits. The intrinsic properties of cellulose, such as its high crystallinity, nanostructured fibrils, and strong hydrogen bonding, provide reinforcement and durability to composites. Meanwhile, other natural polysaccharides such as chitosan, starch, xanthan gum, rheosan and alginate contribute biocompatibility, film-forming ability, and versatility. When appropriately combined, these polysaccharides can enhance mechanical strength and maintain structural integrity in the moist or wet conditions commonly found in agricultural environment. Furthermore, chitosan-based matrices or hydrogels can encapsulate fertilisers, pesticides, or herbicides, allowing for controlled and sustained release. This increases efficiency while minimising environmental contamination [1,2].

Based on multifunctional properties of various natural polysaccharides, we created 3D structure pads based on cellulose fibres dedicated to agricultural cultivation. The effect of different polysaccharides on the dimensional stability, water holding capacity, and wet strength of the pads was analyzed. Three-dimensional porous structure samples (Fig. 1) were fabricated using our proprietary technology involving foamed cellulose pulp and microwave radiation for drying [3] **.**

Figure 1. Cross-section of 3D cellulose pads.

The results showed that combining different ratios of various polysaccharides with cellulose increased the durability of the samples in wet conditions to a level suitable for handling during plant cultivation. Substantial improvements in the mechanical performance of the prepared samples were observed among the tested properties. The water-holding capacity can be adjusted to an optimal level of 85–87% (v/v), maintaining sufficient free pore space

to ensure adequate oxygen availability, which is essential for healthy plant growth. Furthermore, interactions between the chitosan, cellulose fibres and other polysaccharide-based additives significantly improved the dimensional stability of the samples, resulting in enhanced flatness and minimised shrinkage.

The developed method enables the adjustment of material properties, is environmentally friendly, and can be scaled up for production. Cellulose, chitosan and various types of polysaccharide have demonstrated great potential as sustainable building blocks for fibrous materials, making them valuable subjects for collaborative research and development.

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B17

Bolesław Szadkowski, **Anna Marzec**

Lodz University of Technology, Faculty of Chemistry, Institute of Polymer and Dye Technology, Stefanowskiego 16, Poland

FROM NATURE TO PROTECTION: MULTI-FUNCTIONAL CHITOSAN COATINGS WITH NATURAL ADDITIVES FOR ANTIMICROBIAL AND FLAME-RETARDANT COTTON TEXTILES

Chitosan, a naturally derived biopolymer with inherent antimicrobial and film-forming properties, has garnered significant attention as an effective protective coating for cotton fabrics in the development of functional textiles [1, 2]. In response to the escalating demand for sustainable, multifunctional textiles in the healthcare sector, this study presents an innovative, eco-conscious strategy for engineering biodegradable cotton fabrics endowed with dual antimicrobial and flame-retardant functionalities. The proposed methodology leverages newly developed bioactive formulations comprising a biopolymer matrix of chitosan (CS), enriched with natural-derived organic dye and essential oils (EOs). The intrinsic biocidal efficacy of these natural compounds is synergistically coupled with the flame-retardant properties imparted by inorganic fillers including silica (SiO_2), zinc oxide (ZnO), titanium dioxide (TiO_2), and hydrotalcite (LDH).

Spectral and morphological analyses confirmed the successful incorporation of the bioactive coatings, while thermal studies revealed enhanced thermal stability and marked reductions in heat release rates, particularly for samples functionalized with LDH and TiO_2. These exhibited HRR values of 168 and 139 W/g, respectively, signifying a substantial decline from the untreated reference fabric (233 W/g). Antimicrobial assessments against a broad spectrum of pathogenic microorganisms—including Staphylococcus aureus, Escherichia coli, Pseudomonas fluorescens, Bacillus subtilis, Aspergillus niger, and Candida albicans—demonstrated robust inhibitory effects, with enhanced performance observed in formulations incorporating synergistic combinations of plant-derived agents. Soil biodegradability tests further validated the environmental compatibility of the developed materials, showing progressive degradation over a 20-day period.

The findings underscore the viability of facile, non-toxic surface engineering routes to fabricate multifunctional textiles that reconcile performance with sustainability. These bio-based, antimicrobial, and flame-retardant cotton fabrics emerge as promising candidates for next-generation protective materials in medical and hygienic applications.

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B18

Zofia Helena Bagińska, Emilia Szymańska

Medical University of Bialystok, Department of Pharmaceutical Technology, Mickiewicza 2c, 15-222 Białystok, Poland

BARRIER AGENT OR PENETRATION ENHANCER? – THE ROLE OF CHITOSAN IN TOPICAL FORMULATIONS

The barrier effect refers to the ability of a product to protect the tissue against environmental factors [1]. The penetration enhancer is a compound that temporarily increases the epithelial permeability and facilitates drug delivery and deposition. There is contradictory data on whether chitosan acts as a barrier agent or absorption enhancer in topical formulations [2,3]. This study aimed to examine the function of topically applied chitosan gel compared to the biopolymer components most frequently used in topical applications as oral mucosal formulations.

Methodology: Four hydrogels comprised of chitosan (deacetylation degree 80%, Heppe GmbH), polyvinylpyrrolidone, hyaluronate sodium, or xanthan gum with comparable viscosity values were applied in the studies. The ability of the hydrogel to restore barrier epithelial function was assessed by the Transepidermal Water Loss (TEWL) parameter (Tewameter TM 300) in contact with porcine buccal tissue. The formulation's resistance to irritants was examined by ex vivo permeability test (SES GmbH Analysesysteme), which measured the passive diffusion of model chemical agent caffeine across excised porcine cheek [4,5]. Mechanical properties were evaluated by textural analysis (TA.XT.Plus). Commercial oral gel Anaftin® was used as a control.

Results: Permeation studies revealed that chitosan enhanced the diffusion of the irritant agent across the mucosal tissue. This effect might be attributed to impaired mechanical resistance resulting from lower hardness and consistency of chitosan hydrogel compared to other tested preparations. Surprisingly, its presence did not increase drug accumulation in the epithelium, in contrast to xanthan gum, which accelerated both permeability and retention of the model irritant.

Chitosan formulation did not affect tissue integrity, as no alterations in the TEWL parameter of excised tissue were noticed upon single short-term application. In contrast, hyaluronate-based formulation substantially increased, and polyvinylpyrrolidone reduced TEWL values after a single application.

Conclusion: The results demonstrated that chitosan hydrogel acts as a penetration enhancer rather than a barrier-forming agent in contact with oral mucosal tissue.

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B19

Magdalena Gierszewska, **Julia Paluszyńska**, **Ewa Olewnik-Kruszkowska**
Nicolaus Copernicus University in Toruniu, Department of Physical Chemistry and Polymer Physical Chemistry, Gagarina 7 Str., 87-100 Toruń, Poland

EFFECT OF CHITOSAN-BASED PACKAGING FILMS WITH TEA TREE EXTRACT ON THE ANTIOXIDATIVE FEATURES OF COSMETICS DURING ACCELERATED STORAGE

Innovations in cosmetic packaging increasingly demand materials that not only protect the product, but also actively prolong its shelf life in response to oxidative stress. Chitosan, a polysaccharide derived from chitin, with a controllable degree of deacetylation (DDA), offers film-forming capability, biocompatibility, and intrinsic antioxidant and antimicrobial properties. Recent advances show that deep eutectic solvents (DESs) can serve as plasticisers in chitosan films, improving flexibility and barrier functions while introducing additional antioxidant activity when DESs include phenolic or organic acid components. Yu et al. demonstrated chitosan films plasticised with choline-based DESs that exhibited enhanced UV-shielding, antioxidant and antibacterial behaviour [1, 2]. Similarly, composites with pomegranate peel extracts extracted via green DESs incorporated into chitosan significantly increased phenolic content and antioxidant capacity, though at the cost of increased water uptake under high humidity [3].

In cosmetic packaging, especially creams, serums, and masks, oxidative degradation of both the active compounds (e.g. vitamins, oils, and flavonoids) and the container interface accelerates spoilage, discolouration or rancidity. Chitosan-DES films could thus act as an active barrier, scavenging radicals or limiting oxygen permeation, thereby extending cosmetic shelf life. Tailoring the chitosan DDA, DES composition, and film morphology can balance mechanical strength, transparency, water vapour and oxygen barrier, antioxidant capacity and consumer-acceptable aesthetics.

Green tea extract (GTE), rich in polyphenols especially catechins such as epigallocatechin gallate (EGCG), is increasingly studied as an active additive in chitosan and similar biopolymer films. When incorporated, GTE improves free radical scavenging activity, delays lipid oxidation and yellowing of packaged cosmetic formulations, and enhances UV-light barrier properties, thereby helping to preserve sensitive ingredients like oils and vitamins. Moreover, GTE can interact with the polymer matrix (e.g. via hydrogen bonding) to influence film morphology, reducing water vapour permeability and improving mechanical stability under humid conditions, though sometimes with a compromise of flexibility. These effects are highly relevant for cosmetic packaging aiming to extend product shelf life [4].

In this study, chitosan-based films were prepared using a chitosan of defined degree of deacetylation, plasticised with different deep eutectic solvents (DESs) composed of choline chloride, proline or betaine in combination with

selected hydrogen bond donors. The chosen resulting materials were further modified by incorporating green tea extract (GTE, 10 wt%), introduced into the chitosan–DES casting solutions prior to film formation. After solvent evaporation, homogeneous polymer films were obtained and subjected to antioxidant assessment using the DPPH radical scavenging assay. In addition, accelerated storage tests with model cosmetic cream samples were conducted to evaluate the films' potential role as active packaging in extending product stability.

The findings demonstrated that chitosan films plasticised with deep eutectic solvents exhibit distinct antioxidant properties, with the most pronounced activity observed for systems containing malonic acid as a hydrogen bond donor. When applied in direct contact with cosmetic cream, these polymer films significantly influenced the antioxidant profile of the product. Incorporation of green tea extract was particularly effective, as films containing this additive provided stable enhancement of the cream's oxidative resistance during accelerated ageing, with the strongest effect evident after two weeks of storage. Overall, the results highlight the potential of chitosan–DES–GTE films as active cosmetic packaging materials combining mechanical integrity with protective functionality.

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B20

Weronika Gonciarz[1], Marek Brzeziński[2], Artur Lewandowski[3], Paweł Wawrzyniak[3], Magdalena Chmiela[1]

[1] – *University of Lodz, Department of Immunology and Infectious Biology, Institute of Microbiology, Biotechnology and Immunology, Faculty of Biology and Environmental Protection, Banacha 12/16, 90-237 , Poland*

[2] – *Polish Academy of Sciences, 2Centre of Molecular and Macromolecular Studies, Sienkiewicza 112, 90-636 , Poland*

[3] – *Lodz University of Technology, Department of Environmental Engineering, Faculty of Process and Environmental , Zeromskiego 116, 90-924, Poland*

CAN *MYCOBACTERIUM BOVIS* BCG BACILLI BE A CANDIDATE FOR PREVENTING THE DEVELOPMENT OF *HELICOBACTER PYLORI* INFECTION?

Antibiotic and immune resistance of *Helicobacter pylori-*(Hp) prompt search for new antibacterial and pro-immune formulations as *Mycobacterium bovis* BCG-(BCG) with immunomodulatory properties.

Aim: Encapsulation of live BCG (Synthaverse SA, Poland) in mucoadhesive chitosan microparticles (CHI-MPs) to release mycobacteria in acidic or alkaline pH, mimicking stomach/gut conditions; checking whether BCG can reduce Hp colonization and increase the Hp-driven diminishing of monocyte/macrophage phagocytic activity.

Phagocytosis: Human THP-1 monocytes and *Cavia porcellus* macrophages, exposed or not-exposed to Hp, and fluorescently labelled reference Escherichia coli were used. Adhesion: Cavia received per os 0,85% NaCl, Hp alone, BCG alone or BCG and Hp (Ethical approval-58/ŁB45/2016). After 7/28 days, Mucin5 and Hp binding were assessed in gastric tissue specimens fluorescently stained with anti-Mucin5 or anti-Hp antibodies. Primary gastric epithelial cells treated ex vivo with live Hp or Hp components (glycine acidic extract or lipopolysaccharide), alone and/or with BCG, were stained as above. Microparticles: Two pH-dependent MPs variants were BCG encapsulated, enriched with GlcNac-(CHI-Glc-NAc-BCG-MPs) or with Plur-(CHI-Plur-BCG-MPs), to increase bactericidal activity or pH resistance.

Mycobacteria reduced MUC5-dependent Hp gastric adhesion (50%) in Hp inoculated animals or in gastric epithelial cells treated in vitro with Hp components, and upregulated phagocytosis. BCG were successfully released from MPs at pH 3.0 (CHI-GlcNAc-BCG-MPs) or pH 8.0 (CHI-Plur-BCG-MPs).

BCG diminishing gastric Hp adhesion and improving phagocytosis have potential of controlling Hp colonization. CHI-MPs encapsulated with live BCG, releasing mycobacteria in pH dependent manner, can be recommended forassessing their effectiveness towards Hp *in vivo*.

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B21

Katarzyna Struszczyk-Świta[1], **Magdalena Gierszewska**[2]

[1] – *Institute of Molecular and Industrial Biotechnology, Faculty of Biotechnology and Food Sciences, Lodz University of Technology, Stefanowskiego 2/22 St., 90-537 Lodz, Poland*

[2] – *Department of Physical Chemistry and Polymer Physical Chemistry, Faculty of Chemistry, Nicolaus Copernicus University in Toruń, Gagarina 7 St., Toruń, Poland*

AN INNOVATIVE MICROWAVE-ASSISTED APPROACH FOR CHITOSAN EXTRACTION FROM THE BIOMASS OF *MUCOR CIRCINELLOIDES*

Microwave radiation, occupying the electromagnetic spectrum between 300 MHz and 300 GHz, has become a valuable tool in modern bioprocessing due to its ability to deliver rapid and uniform heating. Unlike conventional heating methods, microwaves interact directly with polar molecules within biological materials, enhancing energy transfer efficiency. This makes them particularly useful in processes such as chemical reactions and the extraction of various compounds from biological materials. One of the most promising applications of this technology is microwave-assisted extraction (MAE). MAE offers several advantages over traditional extraction methods, including reduced processing time, lower solvent consumption, and improved extraction yields [1-2]. These features make it especially attractive for isolating natural polymers like chitosan — a biodegradable and biocompatible polysaccharide with broad applications in medicine, agriculture, food packaging, and environmental protection [3-4].

Strains of filamentous fungi such as *Mucor rouxii*, *Rhizopus oryzae*, *Aspergillus niger*, and *Absidia* spp. are well known for their ability to produce chitosan. These fungi are favored not only due to the high content of this biopolymer in their cell walls but also because of their ease of cultivation, making them an attractive and sustainable alternative to crustacean-derived sources [5]. In this context, MAE represents an environmentally friendly and efficient method for enhancing chitosan recovery from filamentous fungal biomass.

In this study, chitosan was successfully extracted from *Mucor circinelloides* biomass using microwave irradiation. A comparative analysis between MAE and conventional heating was performed to evaluate their efficiency and effectiveness in chitosan production. The results indicated that the MAE method significantly reduced the overall processing time, accelerating the extraction process. Despite the shorter extraction duration, the chitosan obtained via microwave treatment exhibited physicochemical properties and quality comparable to that extracted using conventional heating. These findings suggest that MAE is not only a time-efficient technique but also a viable alternative for producing high-quality chitosan from fungal biomass. Overall, the study highlights the potential of microwave technology to enhance the sustainability and scalability of chitosan production, particularly for industrial applications.

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B22

César I. Hernández Vázquez[1], **Zbigniew Draczyński**[2]

[1] – *Łukasiewicz Research Network-Lodz Institute of Technology, Type department, 19/27 M. Skłodowskiej-Curie, 90-570, Lodz, Poland.*

[2] – *Lodz University of Technology, Institute of Materials Science of Textiles and Polymer Composites, 116 Żeromskiego 90-924, Lodz, Poland.*

COMPARATIVE IMPACT OF CARBOXYLIC ACID SOLVENTS ON WET-SPUN FIBERS FROM DIFFERENT SOURCES

Chitosan continues to receive attention in the scientific community due to its bioactivity, biodegradability, and biocompatibility, making it a versatile natural polymer for biomedical applications. Its modifiable functional groups enable fine-tuning of material properties without compromising its biopolymeric nature, supporting ongoing efforts to optimize its structural and mechanical performance through improved processing techniques.

This study investigates the preparation and characterization of wet-spun chitosan fibers derived from two biological sources—crustacean shells and fungal cell walls—using three carboxylic acid solvents: acetic, lactic, and citric acid. To ensure a controlled comparison, both chitosan types were dissolved at the same concentration (6% w/v) in each solvent, and wet spinning was performed into a 4% NaOH coagulation bath. While both chitosan sources were processed under identical conditions, intrinsic differences in molecular characteristics, such as degree of deacetylation or molecular weight may also contribute to performance variations.

Fiber morphology and microstructure were assessed via scanning electron microscopy (SEM), and mechanical performance was evaluated through tensile testing and elongation at break.

The results demonstrate that solvent type significantly influences fiber diameter and mechanical properties, with similar trends observed across both chitosan sources. In particular, fibers spun using acetic acid exhibited comparable morphology and mechanical characteristics regardless of biological origin, suggesting a shared fiber-forming mechanism under those conditions. In contrast, lactic and citric acid produced source-dependent differences in fiber structure and performance.

This comparative analysis underscores the importance of solvent selection in tailoring the physical properties of chitosan fibers and provides insight into solvent–polymer interactions that influence fiber formation. The findings offer practical guidance for optimizing processing parameters in the development of chitosan-based materials for biomedical applications.

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B23

Joanna Kluczka, **Łukasz Wujcicki**, **Tomasz Mańdok**
Silesian University of Technology, Faculty of Chemistry, B. Krzywoustego Str. 6, Gliwice, Poland

USE OF CHITOSAN MODIFIED WITH LANTHANIDE SALTS FOR SORPTION REMOVAL OF ANIONS FROM WATER

Boron is an essential element for both plants and living organisms; however, excessive amounts can lead to reduced crop yields, damage to crops, and health issues in humans, particularly affecting the nervous system. Similarly, phosphorus, a well-known nutrient found in artificial fertilizers and animal feed, can cause water eutrophication and the death of aquatic life when it enters water bodies in excessive concentrations.

There are established methods for reducing the concentration of harmful ions in the aquatic environment, including precipitation, ion exchange, and membrane techniques [1-4]. However, current regulations necessitate the development of methods that utilize non-toxic reagents and do not generate waste. To address these needs, we have designed new sorbents based on chitosan.

Lanthanide salts were incorporated into the chitosan structure to enhance its sorption capacity for anionic pollutants, such as fluorides, nitrates, borates, and phosphates. By dissolving and mixing chitosan with cerium or lanthanum chloride, a single-step coagulation method was used to create hybrid hydrogel granulates enriched with lanthanide ions [5,6].

Next, the structures of these hybrid hydrogels were examined using FTIR, SEM-EDS, and XPS analyses, confirming the formation of spheres with a novel composition and structure. Then the characterized sorbents were employed to remove borate and phosphate ions through sorption, initially using batch systems and subsequently column sorption techniques. The results demonstrated that the chitosan-lanthanum hybrid hydrogel effectively removed boric acid from an aqueous solution at pH 4, achieving a maximum sorption capacity of 128 ± 2 mg/g after 24 hours of the sorption process [6]. Meanwhile, the chitosan-cerium hydrogel reached a maximum sorption capacity of 95 ± 2 mg/g at pH 7 within the same time frame [5]. Furthermore, the chitosan-cerium hydrogel exhibited an impressive phosphate ion removal efficiency of over 98%, which is approximately four times higher than that of the unmodified chitosan-based hydrogel. The best sorption capacity for phosphates on the chitosan-cerium hydrogel was recorded at 71.6 mg/g, derived from a solution with an initial phosphate concentration of 9.76 mg/dm³ at pH 7 (typical for real water), using a sorbent dose of 1 g/dm³ and at a temperature of 20°C [7].

To sum up, hybrid chitosan and lanthanide hydrogels efficiently sorb borate and phosphate anions. Furthermore, a convenient granular form of

hydrogels is suitable for separation processes. Together, these qualities make them promising eco-sorbents for treating water and wastewater.

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B24

Marta Wasilewska[1], Beata Gutarowska[1], Anna Masek[2]

[1] – *Lodz University of Technology, Faculty of Biotechnology and Food Sciences, Wólczańska 171/173, Poland*

[2] – *Lodz University of Technology, Faculty of Chemistry, Stefanowskiego 16, Poland*

CHITIN FROM INSECT EXOSKELETONS AS A BIOTECHNOLOGICAL PACKAGING MATERIAL WITH ANTIMICROBIAL PROPERTIES

The dynamic development of the eco-packaging market drives the search for innovative solutions based on renewable raw materials. Chitin and its derivative – chitosan – obtained from insect-based waste present a promising alternative to conventional packaging materials. Their biodegradability and potential antimicrobial activity are particularly relevant for extending the shelf life of stored food.

The aim of this project is to develop biodegradable packaging materials in the form of compatible PLA–chitosan polymer blends, using exoskeletons of yellow mealworm (*Tenebrio molitor*) as the source. The work involved optimization of chitin extraction and its deacetylation to chitosan, development of procedures for biopolymer blending, and evaluation of the resulting materials. Biopolymers and PLA–chitosan blends were thoroughly characterized using appropriate analytical techniques. The analyses included spectroscopic studies (FTIR), surface properties (goniometry), mechanical properties (tensile strength, elongation at break), thermal behavior (DSC, TG), and surface morphology (microscopy).
The antimicrobial activity of the materials was also tested against bacteria, yeasts, and molds.

Optimized chitosans demonstrated antimicrobial activity against *E. coli*, *B. subtilis*, and *S. aureus*, with the degree of purification and molecular weight of chitosan identified as key factors. Comprehensive characterization of chitosans and polymer blends in further studies will help define their potential applications in sustainable packaging.

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B25

Bianca-Iustina Andreica, **Irina Rosca**, **Luminita Marin**

Petru Poni Institute of Macromolecular Chemistry, Polycondensation and Thermostable Polymers, Grigore Ghica Voda Alley, 41A, Romania

BIOMEDICAL APPLICATIONS OF HYDROGELS DESIGNED FROM CHITOSAN SCHIFF BASE DERIVATIVES

The development of chitosan-based biomaterials remains an active area of research, driven by their remarkable biological properties and sustainable origin. In recent decades, particular attention has been devoted to water-soluble chitosan derivatives, which are especially suitable for biomedical applications. Among them, quaternary ammonium salts of chitosan show strong potential for practical use across diverse biomedical fields, including antimicrobial products, gene therapy, drug delivery, wound healing, tissue engineering, and cosmetics [1].

Studies on chitosan-based hydrogels highlighted a mild crosslinking strategy involving the condensation of monoaldehydes with chitosan, leading to imination and subsequent self-assembly of the resulting imine units into crosslinking clusters. This approach has proven effective for generating hydrogels with tunable properties tailored to specific applications [2].

Building on this foundation, the present study reports the synthesis and characterization of hydrogels derived from quaternized chitosan, crosslinked with salicylaldehyde, for biomedical use. A series of 15 hydrogels was prepared in aqueous media through condensation reactions at varying amine-to-aldehyde molar ratios, ranging from 1:1 to 15:1.

All the hydrogels successfully passed the inverted tube test. The gelation mechanism was attributed to two key processes: imination, confirmed by FTIR and NMR spectroscopy, and self-assembly of the imino-HTCC derivatives into a three-dimensional network, as demonstrated by WXRD and POM analyses. The dried hydrogels displayed a porous morphology, as observed by SEM, which is highly advantageous for wound healing applications, since it facilitates oxygen and nutrient exchange, as well as fluid absorption. Upon rehydration, the materials rapidly restored their hydrogel state in less than one hour, ensuring quick usability at the application site. Moreover, they exhibited superabsorbent behavior, which is crucial for effectively managing wound exudates and maintaining a moist healing environment.

The hydrogels demonstrated self-healing capacity, confirmed by complementary techniques. The dissolution rate of the xerogels/hydrogels in aqueous media was found to be dependent on both crosslinking density and pH, allowing for a controlled degradation profile. Such biodegradability ensures that the materials do not accumulate in the body, making them safe for biomedical use.

In addition to their favorable physical properties, the hydrogels exhibited notable biological performance. They displayed strong *in vitro* antimicrobial activity, an essential feature for preventing wound infections, which remain a major complication in wound management. Furthermore, *in vivo* biocompatibility tests on mice confirmed that the materials are well tolerated without eliciting adverse immune responses.

Altogether, the unique set of features—including rapid gelation, porosity, high swelling capacity, self-healing ability, tunable degradation, antimicrobial activity, and biocompatibility—positions these hydrogels as highly promising candidates for wound healing applications.

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Session C

Bianca-Iustina Andreica, **Alexandru Anisiei**, **Irina Rosca**, **Luminita Marin**
Petru Poni Institute of Macromolecular Chemistry, Polycondensation and Thermostable Polymers, Grigore Ghica Voda Alley, 41A, Romania

NANOFIBERS BASED ON CHITOSAN/QUATERNIZED CHITOSAN SCHIFF BASES DESIGNED AS HEMOSTATIC BANDAGES

Uncontrolled bleeding is a leading cause of death globally, responsible for over 5 million fatalities annually and significant economic burden. This has accelerated the development of advanced hemostatic materials for emergency use in both civilian and battlefield settings [1]. Chitosan has emerged as an excellent hemostatic agent due to the combination of hemostatic, antibacterial, anti-inflammatory, wound healing, biocompatible, biodegradable, and non-toxic properties [2]. Among candidate materials, nanofibers offer unique advantages such as high porosity, a large surface-to-volume ratio, conformability, and ease of use [3]. Furthermore, through the careful selection of functional components, composite nanofiber dressings can be engineered not only to control bleeding effectively but also to enhance wound healing.

In this context, the aim of this study was to obtain composite nanofibers with rapid hemostatic effect and wound healing capability. To achieve this goal, the fibers' components were selected based on their properties, namely: ***chitosan*** (CS), which has demonstrated hemostatic activity and is non-toxic; ***quaternized chitosan*** (HTCC), which offers the advantages of water solubility, enhanced antimicrobial activity, and improved hemostatic properties; ***vanillin (V)***, which forms Schiff bases with the amino groups of CS/HTCC and consequently allows its release during the healing process, contributes to re-epithelialization and reduces the risk of bacterial infections; and ***polyethylene oxide*** (PEO), which acts as a good co-spinning agent for CS/HTCC and improves the mechanical properties of the fibers.

The obtained materials were thoroughly characterized. FTIR and ^{1}H-NMR confirmed the covalent bonding of vanillin to chitosan and quaternized chitosan *via* reversible imine linkages, along with intermolecular interactions. XRD and POM microscopy revealed the semicrystalline nature of the fibers due to phase segregation of PEO-rich domains, while SEM showed a well-formed nanofiber network. The fibers exhibited high moisture uptake (~30 g/g) and blood adsorption capacities, along with significant degradability over 21 days in PBS media containing lysozyme. The reversible imine bonds allowed controlled, stimulus-responsive vanillin release. Quaternized chitosan also enhanced antioxidant activity up to 68% through synergistic activation of hydroxyl groups.

The fibers exhibited strong inhibitory effects against relevant pathogens, including Gram-positive and Gram-negative bacteria, as well as yeasts. Their adhesiveness and water vapor transmission rate were comparable to those of

commercial hemostatic dressings. Blood coagulation capacity, evaluated visually, by UV-Vis spectroscopy, and by SEM, showed superior performance compared to a commercially available hemostatic sponge, with the fibers able to absorb and coagulate large amounts of blood in a short time relative to their weight.

All these data confirm that the proposed design was validated, and the vanillin-loaded composite nanofibers represent valuable materials for the development of hemostatic dressings with potential roles in subsequent wound healing.

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Katarzyna Kresse-Walczak [1], **Katrin Binz** [2], **Meissner Heike** [2], **Klaus Boening**[2]

[1] – *Aarhus University, Department of Dentistry and Oral Health, Vennelyst Boulevard 9, Denmark*

[2] – *Carl Gustav Carus Faculty of Medicine, TU Dresden, Department of Prosthetic Dentistry, Fetscherstr. 74, Germany*

IN VITRO SIMULATION OF MINERALIZED BIOFILM USING CHITOSAN-BASED ARTIFICIAL CALCULUS EQUIVALENTS

Objective: Dental calculus forms through the mineralization of biofilm with calcium phosphates and contributes significantly to the progression of oral diseases. As chitosan possesses favorable material properties relevant to biofilm control, the objective of this study was to simulate the abrasion resistance of dental calculus using artificial calculus equivalents (ACEs) composed of chitosan (CS), methylcellulose (MC), and tricalcium phosphate (TCP).

Materials and Methods: To establish the *in vitro* model, cylindrical PMMA specimens were silicatized on one end to increase hydrophilicity. Six ACE formulations (ACE1 - ACE6) were prepared in 100 g of 2% acetic acid. ACE1 and ACE2 contained 2.0 g of CS and no MC, with TCP amounts of 2.0 g and 4.0 g, respectively. ACE3 consisted of 1.0 g CS, 1.0 g MC, and 2.0 g TCP. ACE4 included 0.4 g CS, 1.6 g MC, and 2.0 g TCP. ACE5 and ACE6 further reduced the CS content to 0.3 g and 0.2 g, respectively, while increasing MC to 1.7 g and 1.8 g, with TCP maintained at 2.0 g. Each formulation (1.15 mL) was applied to silicatized PMMA surfaces (n = 8 per group), followed by drying, neutralization with sodium hydroxide, rinsing with distilled water, and re-drying. Abrasion was performed using a standardized, commonly used dental hand scaler that was securely fixed in a toothbrush simulator, with increasing stroke counts (1, 2, 4, 8, and 16). ACE loss was visually categorized into four levels:: <20%, 20 to <50%, 50 to <80%, and 80 to100%. ACE3 and ACE4 were further evaluated under moist conditions.

Results: Under dry conditions, ACE1 and ACE2 required 8 strokes for 50 to 100% removal. ACE3 and ACE4 reached this range after 4 strokes. ACE5 showed 80 to 100% removal after 2 strokes, and ACE6 1 stroke. Under moist conditions, ACE3 showed progressive abrasion: 20 to <50% after 1 stroke, 50 to <80% after 2, and 80 to100% after 4. ACE4 reached 80 to 100% after 1 stroke.

Conclusion: This study develops an effective *in vitro* model for simulating the abrasion resistance of dental calculus and demonstrates that this property can be modulated through the chitosan–methylcellulose ratio. The presence of moisture significantly enhances ACE removal. Among all tested formulations, ACE3 under moist conditions seems to most closely resembled the clinical behavior of mineralized biofilm. These findings underscore the applicability of chitin-derived polymers, particularly chitosan, in developing standardized testing substrates for *in vitro* studies, highlighting their relevance in biomedical material research.

Magdalena Paczkowska-Walendowska[1], Anna Rył[2], Piotr Owczarz[2], Jakub Kwiatek[3], Judyta Cielecka-Piontek[1]

[1] – *Department of Pharmacognosy and Biomaterials, Poznan University of Medical Sciences, Rokietnicka 3, 60-806 Poznan, Poland*

[2] – *Department of Chemical and Molecular Engineering, Lodz University of Technology, Wolczanska 213, 93-005 Lodz*

[3] – *Kwiatek Dental Clinic Sp. z o.o., Kordeckiego 22, 60-144 Poznan, Poland*

BAICALEIN-LOADED CHITOSAN FILMS: A NOVEL BIOMATERIAL FOR THE TREATMENT OF ORAL INFECTIONS

Chitosan has attracted increasing interest in the development of innovative biomaterials for localized drug delivery systems due to their biocompatibility, biodegradability, mucoadhesive properties, and inherent antimicrobial activity [1]. In this study, we present the formulation, characterization, and evaluation of baicalein-loaded chitosan-gelatin films, developed as multifunctional membranes for potential application in the treatment of oral infections and in regenerative dentistry. The films were produced using the solvent casting method, with composition and chitosan molecular weight optimized via a 3^2 factorial design. The experimental variables included chitosan molecular weight (low, medium, and high) and the ratio of chitosan to gelatin, resulting in nine formulations (F1–F9).

Physicochemical analyses—including microscopy, scanning electron microscopy (SEM), X-ray powder diffraction (XRPD), and Fourier-transform infrared spectroscopy (FTIR)—confirmed uniform dispersion of baicalein within the polymer matrix, particularly for formulations containing medium molecular weight chitosan (CS MMW). XRPD demonstrated the amorphization of baicalein upon incorporation into the films, indicative of strong interaction with the polysaccharide-protein matrix and potential enhancement of solubility. Mechanical testing revealed that all formulations exhibited Young's modulus and yield stress values suitable for biomedical applications, with a clear correlation between chitosan content and film flexibility or stiffness. Importantly, increasing chitosan content and molecular weight led to denser matrix formation, which slowed the release of baicalein as confirmed by dissolution studies. All systems followed zero-order kinetics, enabling predictable, sustained drug delivery.

Biological evaluations showed that the films retained and even enhanced baicalein's antioxidant and anti-inflammatory properties. The strongest antioxidant activity (DPPH assay) was observed in formulations with high chitosan molecular weight and low gelatin content, whereas anti-inflammatory activity (hyaluronidase inhibition) improved with both increasing chitosan concentration and molecular weight. Furthermore, the optimal formulation (F5: CS MMW 2%, Gel 2%) demonstrated a favorable balance of mechanical strength, drug release

profile, and biological efficacy. This film inhibited Streptococcus mutans growth, showed no cytotoxicity in fibroblast cultures (MTT assay), and exhibited ideal surface interactions in tests simulating contact with blood and injectable platelet-rich fibrin (iPRF). The films adhered superficially without excessive fluid absorption, which is crucial for maintaining dimensional stability and barrier function in clinical conditions.

The results underscore the versatility of chitosan as a matrix for localized drug delivery systems, demonstrating that its properties can be fine-tuned by adjusting molecular weight and composition to achieve desired mechanical and biological performance. The study highlights the potential of baicalein-loaded chitosan films as multifunctional membranes for oral applications, particularly in post-surgical care, periodontal therapy, and guided tissue regeneration. The modular design of the system allows future integration of additional bioactive agents, paving the way for advanced, personalized therapeutic solutions.

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Session D

Joanna Odrobińska-Baliś[1], Magdalena Procner[1], Kinga Krużel[1], Magdalena Regulska[2], Monika Leśkiewicz[2], Dorota Duraczyńska[1], Szczepan Zapotoczny[3], Władysław Lasoń[2] , Krzysztof Szczepanowicz[1]

[1] – *Jerzy Haber Institute of Catalysis and Surface Chemistry Polish Academy of Sciences, Niezapominajek 8, 30-329 Kraków, Poland*

[2] – *Maj Institute of Pharmacology Polish Academy of Sciences, Smętna 12, 31-343, Kraków, Poland*

[3] – *Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387, Kraków, Poland*

CHITOSAN NANOCAPSULES FOR ENCAPSULATION OF LIPOPHILIC NEUROPROTECTANTS: TOWARD ADVANCED CNS DRUG DELIVERY SYSTEMS

The growing burden of neurodegenerative diseases such as Alzheimer's, Parkinson's, and stroke demands innovative strategies for effective brain-targeted drug delivery. One of the key challenges in current neurotherapies lies in overcoming the low bioavailability and limited brain penetration of neuroprotective agents. In this study, we present a surfactant-free nanocarrier system based on chitosan-derived amphiphilic polymers that self-assemble into stable nanocapsules with oily cores in aqueous environments. This design leverages the natural affinity of hydrophobic side chains for the oil phase, forming well-defined nanocapsules without the need for low-molecular-weight emulsifiers.

The oily cores were successfully loaded with carnosic acid—a model compound with established neuroprotective properties. The resulting nanocapsules demonstrated high encapsulation efficiency, long-term colloidal stability, and hydrodynamic diameters below 150 nm. Morphological characterization was performed via scanning electron microscopy (SEM) and confocal microscopy, confirming uniform capsule structure. In vitro assays in neuronal cell models confirmed both the absence of cytotoxicity and the neuroprotective activity of the encapsulated compound. These findings highlight the potential of this biopolymer-based delivery system as a promising platform for brain-targeted neuroprotective therapies.

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Joanna Kurczewska
Adam Mickiewicz University, Faculty of Chemistry, Uniwersytetu Poznańskiego 8, 61-614 Poznań, Poland

CHITOSAN-BASED HYDROGEL BEADS INCORPORATING MOLECULARLY IMPRINTED POLYMERS FOR SELECTIVE ADSORPTION OF PHARMACEUTICALS

The global challenge of ensuring access to safe drinking water highlights the urgent need for efficient strategies to eliminate contaminants from aquatic environments. Among the most common pollutants are heavy metals, organic dyes, and pharmaceutical residues, which contribute significantly to ongoing water quality degradation. Hydrogel beads have emerged as promising adsorbent materials for the removal of various impurities. The effective design of hydrogel beads, particularly those utilizing natural polysaccharides and incorporating additional components, can enhance their performance for specific applications. In this regard, the aim of our research was to develop and characterize composite materials based on chitosan for the removal of selected pharmaceuticals.

A series of hybrid systems were obtained under mild conditions by combining chitosan (CS) with molecularly imprinted polymers (MIPs), and were investigated as potential adsorbents of ibuprofen (IBU) [1] and tetracycline (TC) [2]. Several parameters – adsorbent dose, pH, adsorbate initial concentration, contact time, temperature - influencing adsorption were analyzed to optimize the process.

The maximum adsorption capacities of IBU and TC were approximately 104 and 186 mg g^{-1}, respectively. The adsorption process was spontaneous and followed the Freundlich isotherm and pseudo-second-order kinetic models. The CS-based hydrogel beads retained their selectivity in the presence of other molecules and maintained their effectiveness in real water samples. The materials were reusable over multiple adsorption-desorption cycles, thereby reducing overall costs. Their adsorption efficiency was primarily attributed to pore-filling, accompanied by the simultaneous contributions of electrostatic interaction, complexation, H-bonding, and π-π electron donor-acceptor effect. Our findings indicate the considerable potential of the investigated materials in the effective and selective removal of pharmaceutical contaminants from water.

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Sabrina Scheele, **Irina Kuznik**, **Lukas Benecke**, **Chokri Cherif**
TUD Dresden University of Technology, Institute of Textile Machinery and High Performance Material Technology (ITM), Dresden, Germany

CHITIN AND CHITOSAN FILAMENT YARNS FROM VARIOUS NATURAL SOURCES FOR MEDICAL AND TECHNICAL APPLICATIONS

Chitin and chitosan are natural biopolymers that exhibit excellent biocompatibility, biodegradability, and high mechanical strength. These properties render them particularly well-suited for medical applications, including use as implants, wound dressings, or absorbable textiles. However, their broader implementation is limited by significant processing challenges – especially related to solubility, molecular weight variability, and the formation of stable filament structures. This research addresses these gaps by developing adapted spinning processes and solvent systems specifically tailored for low-molecular-weight fungal chitosan, aiming to enable its use in high-performance filament yarns for biomedical applications.

The advent of novel solvent-based spinning methodologies has enabled the processing of chitin and chitosan from an array of natural sources, encompassing fungi, insects, and marine organisms, into filament yarns. The adapted solution and process conditions enable stable yarn formation, regardless of the provenance and molecular properties of the biopolymers used. This development offers novel opportunities for the utilization of these sustainable raw materials in medical-technical textile applications.

Our research focusses on the potential of chitin and chitosan from different natural sources – including marine, insect-based, and fungal origins – for the production of medically applicable multifilament yarns. These raw materials differ significantly in their molecular weight, degree of deacetylation, and solubility behavior, which directly influence their spinnability and the properties of the resulting filaments. To evaluate and compare the processability and material performance, key parameters such as solution viscosity, filament fineness, mechanical strength, and homogeneity were assessed. Characterization methods included light and scanning electron microscopy (SEM), tensile testing, and Fourier-transform infrared spectroscopy (FTIR) to investigate morphology, structure, and chemical composition. By systematically adjusting the solvent systems and spinning parameters, it was possible to process chitin and chitosan of varying provenance into homogeneous, fine filament yarns. The produced yarns exhibit uniform morphology and promising mechanical characteristics suitable for use in medical and health-related textile applications.

The results demonstrate the potential of chitin and chitosan of different natural sources for the development of functional filament yarns in bioresorbable medical textiles. Fungal chitosan, with its typically low molecular weight and high

biocompatibility, shows particular promise for applications in wound healing, drug delivery, and tissue regeneration. In contrast, marine-derived chitosan, due to its higher molecular weight and greater mechanical stability, may be better suited for load-bearing applications or long-term structural functions in medical or technical textiles. Subsequent studies will focus on the dynamics of drug release and the development of functional coatings.

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Daniela Ailincai, **Luminita Marin**
Petru Poni Institute of Macromolecular Chemistry, Polycondensation and Thermostable Polymers, Grigore Ghica Voda Alley, 41A, Romania

HYDROGELS BASED ON IMINOCHITOSAN DERIVATIVES FOR BIOMEDICAL APPLICATIONS

Hydrogels are three-dimensional, cross-linked polymer networks that can absorb and retain large amounts of water or biological fluids without dissolving [1]. Their unique properties, which can be precisely tuned for specific applications, make them highly suitable for a wide range of biomedical uses. Therefore, the objective of this study was to develop formulations based on biocompatible hydrogels with desirable and promising properties suitable to be used in the biomedical field. Elastic hydrogels were obtained by crosslinking chitosan with two aldehydes [2]. The hydrogels presented biocompatibility and high antimicrobial activity against fungi, gram-positive and gram-negative bacteria and they were further used for the development of drug delivery systems by encapsulating two bioactive agents: one with the aim to increase the antimicrobial activity and the other one to confer anticancer activity to the systems. In this manner, materials with adequate properties to be used in biomedical applications were obtained. The developed systems were thoroughly characterized. Morphological analysis indicated uniform incorporation of the bioactive agents within the hydrogel matrix, while FTIR and WXRD analyses confirmed strong interactions between the active compounds and the polymer network. The systems demonstrated great biological properties, including antioxidant and antimicrobial effect, along with biocompatibility and biodegradability. *In vitro* release studies showed that the formulations could sustain the release of incorporated agents over multiple days through complex mechanisms including diffusion, swelling, and erosion.

All the obtained data revealed that the designed materials present high potential to be used in the biomedical field.

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Anna Rył[1,2], Andrea Jannina Fernandez[2], Manlio Tassieri[2], Piotr Owczarz[1]

[1] – *Lodz University of Technology, Department of Chemical and Molecular Engineering, 213 Wolczanska, 93-005 Lodz, Poland*

[2] – *University of Glasgow, Division of Biomedical Engineering, 11 Chapel Ln, Glasgow G11 6EW, United Kingdom*

MAPPING THE MULTISCALE VISCOELASTIC LANDSCAPE OF CHITOSAN SOLUTIONS

When designing biopolymer systems for biomedical, pharmaceutical, or cosmetic applications, it is essential to precisely characterise the experimental medium in order to determine the mechanical state of the matrix intended to carry drugs or cells. This is because the conformational state of polymer chains significantly influences key phenomena, including the diffusion of dispersed systems [1].

To assess viscoelastic properties, bulk rheological tests are typically performed over a range of frequencies to obtain the storage modulus (G') and loss modulus (G''), which quantify the elastic and viscous components, respectively. However, in many cases, limitations of rotational rheometers and the nature of bulk measurements prevent the acquisition of reliable data over sufficiently broad frequency or deformation ranges to fully resolve the dynamic mechanisms at play within the material.

To address this, we characterised chitosan solutions of varying polymer and acetic acid concentrations using both classical oscillatory shear rheometry and microrheological techniques, including dynamic light scattering (DLS) [2] and optical tweezers (OT) [3]. Additionally, blends of chitosan with different molecular weights (low and high) were examined. All experiments were conducted at 21°C to ensure comparability across methods.

The resulting data allowed us to evaluate the influence of chitosan and acetic acid concentrations on G' and G''. From these measurements, relaxation times were extracted, enabling investigation of molecular dynamics such as segmental relaxation, conformational rearrangements, and the elasticity of chain segments as a function of deformation frequency. The combination of bulk and microrheological approaches provided access to a remarkably broad frequency range, spanning from 10^{-2} to 10^{6} rad/s. This corresponds to timescales ranging from ~10^{-6} to 10^{2} seconds, thereby encompassing dynamic processes from bond vibrations and sub-10 nm segmental motions to full-chain displacements and macroscopic reorganisation (>100 nm) [2].

Results will be compared to those obtained for other biopolymers, including xanthan gum and sodium alginate. Finally, technical considerations associated with the measurement protocols will be discussed, as they can significantly affect the accuracy and reproducibility of the results.

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Session E

Izabela Myjak[1], **Marcin Barburski**[1], **Zbigniew Draczyński**[2], **Dominik Sikorski**[2],

[1] – *Lodz University of Technology, Faculty of Material Technologies and Textile Design, Institute of Architecture of Textiles, 116 Zeromskiego Street 90-543 Lodz, Poland*

[2] – *Lodz University of Technology, Faculty of Material Technologies and Textile Design, Institute of Textiles, 116 Zeromskiego Street, 90-543 Lodz, Poland*

MODIFICATION OF CELLULOSE-BASED TEXTILE PRODUCTS WITH CHITOSAN SALT

In response to escalating environmental and public health imperatives, as well as stringent regulatory controls on toxic auxiliaries, the present investigation delineates advanced methodologies for the sustainable functionalization of cellulose textiles using chitosan salts. Cellulose substrates were impregnated with chitosan under controlled pH conditions. Subsequently, the treated textiles were thermally laminated with polylactic acid (PLA) nonwovens to fabricate biocomposite laminates.

Characterization of the modified fabrics was conducted via attenuated total reflectance Fourier-transform infrared spectroscopy (FTIR-ATR), which evidenced characteristic chitosan–cellulose interactions through shifts in amide and hydroxyl absorption bands. Scanning electron microscopy (SEM) revealed a homogeneous chitosan coating and intimate interfacial bonding between the textile and PLA layers. Flammability performance was quantified by measuring the limiting oxygen index (LOI), whereby chitosan incorporation yielded a statistically significant increase in LOI values compared to untreated samples, indicating enhanced flame-retardant efficacy.

The produced PLA–chitosan–cellulose composites fulfill circular economy criteria by utilizing biodegradable components and eliminating reliance on halogenated flame retardants. These findings establish a foundation for the scalable production of sustainable, high-performance textile materials with multifunctional attributes.

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Julia Kietlińska[1], **Anna Marzec**[2], **Zbigniew Draczyński**[3], **Dominik Sikorski**[3]

[1] – *Lodz University of Technology, Faculty of Materials Technology and Textile Design, ul. Żeromskiego 116, 90-543 Łódź, Poland*

[2] – *Lodz University of Technology, Faculty of Chemistry, Institute of Polymer and Dye Technology, ul. Stefanowskiego 16, 90-537 Łódź , Poland*

[3] – *Lodz University of Technology, Faculty of Materials Technology and Textile Design, Institute of Textile Engineering, ul. Żeromskiego 116, 90-543 Łódź, Poland*

INVESTIGATION OF ORGANIC PLASTICIZERS AND THEIR IMPACT ON THE ELASTICITY OF CHITOSAN FILMS FOR FUNCTIONAL COATING APPLICATIONS

Chitosan, a natural biopolymer obtained from chitin, has garnered significant interest in the textile sector owing to its biodegradability, biocompatibility, and multifunctional characteristics. It is frequently employed as a functional finishing agent or as a constituent in fiber production. However, the intrinsic rigidity and brittleness of neat chitosan films constrain their applicability in flexible and durable textile systems [1-2].

The present study aims to enhance the flexibility of chitosan films by incorporating various organic plasticizers into chitosan solutions. Among the plasticizers evaluated was sodium carboxymethyl cellulose (CMC), selected for its documented efficacy in improving mechanical performance while retaining the biodegradability and eco-compatibility of the polymer matrix. The overarching goal was to develop sustainable, antibacterial textile materials with sufficient mechanical robustness for coating and composite applications.

Chitosan film samples—with and without plasticizers—were fabricated via solution casting, followed by controlled drying and equilibration. The modified films were characterized differential scanning calorimetry (DSC) to assess changes in thermal transitions. Mechanical properties were determined through tensile testing, measuring both tensile strength and elongation at break, critical parameters for evaluating suitability in textile coatings.

Results demonstrated that all tested plasticizers increased the elongation at break of chitosan films, indicating a marked improvement in flexibility, while tensile strength remained largely unaffected. DSC analysis revealed only minor shifts in the glass transition temperature, which—depending on the plasticizer type—occurred toward slightly lower or higher temperatures.

In conclusion, the incorporation of organic plasticizers—especially glycerol stearate—effectively tailors the mechanical behaviour of chitosan films by enhancing elasticity without compromising strength or thermal properties, thereby expanding their potential for use in flexible, biodegradable coatings and flat textile substrates. These findings support the development of environmentally benign, antibacterial textile products for applications such as medical textiles,

protective garments, and other functional fabrics requiring a balance of sustainability and performance.

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Akshayaa Sankar[1], **Ramyadevi Durai**[1], **Vedha Hari B Narayanan**[1], **Marek Brzeziński**[2]

[1] – *SASTRA Deemed University, School of Chemical & Biotechnology, Pharmaceutical Technology Lab, Thirumalaisamudram, Thanjavur- 613401, India*

[2] – *Centre of Molecular and Macromolecular Studies, Polish Academy of Science,* Sienkiewicza 112, 90-363 Lodz, Poland

SPRAY DRIED EFAVIRENZ LOADED CHITOSAN NANOPARTICLE: A LONG-ACTING ANTI-RETROVIRAL THERAPY FOR HIV

Nanoparticle drug delivery offers a promising strategy in HIV treatment by enhancing the bioavailability of Anti-retroviral drugs (ARVs) and improving therapeutic outcomes. Long-acting therapies in HIV are essential in achieving patient adherence and minimizing dosage frequency. This study focuses on the synthesis of **chitosan-based polymeric nanoparticles** for the **anti-HIV drug efavirenz**, with the goal of achieving a sustained, long-acting release profile

Nanoparticles composed of chitosan extracted from the shell of ***Portunus sanguinolentus*** (Crab) and the anti-HIV drug **Efavirenz** (BCS Class II) have been successfully synthesized using a **spray-drying** technique and characterized for morphology, particle size, surface area, thermal, and chemical stability.

The nanoparticles were synthesized using varying drug-to-polymer ratios via spray drying, resulting in smooth, spherical particles (200-500 nm) with a PDI of 0.541, zeta potential of 3-8 mV, and 71% maximum drug content. Fourier Transform Infra-red Spectroscopy (FT-IR) and TGA-DSC (Thermogravimetric and Differential Scanning Calorimetry) analyses confirmed drug compatibility and stability post-spray drying. *Ex vivo* permeation studies demonstrated high permeability of the spray-dried particles through goat skin. In vitro release studies in distilled water, phosphate buffer (pH 7.4), and 0.1N HCl (pH 1.2) showed a steady release, with 70% drug release achieved in 72 hours across all media. In consonance with the data obtained, the formulated nanoparticles exhibited promising aspects of long-acting therapy for HIV

Keywords: Nanoparticle drug delivery, Long-Acting Nano formulation, Spray Drying.

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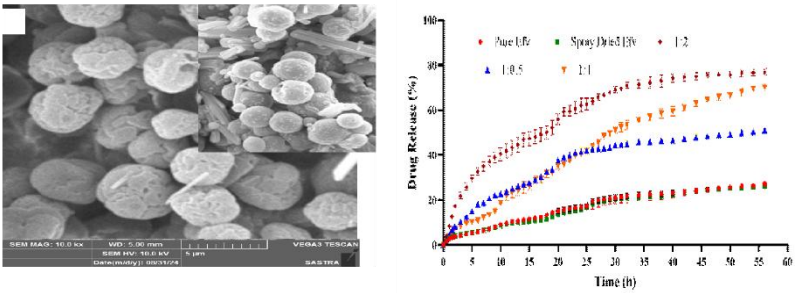

Fig. 1. Scanning Electron Microscopic image and drug release pattern of Efavirenz loaded chitosan nanoparticles.

Table:1. Physicochemical characteristics of Efavirenz loaded chitosan nanoparticle.

Formulation ratio (Efv: Chi)	Size (nm)	PDI	Zeta Potential(mV)	Drug Content (%)
1:0.5	562.7	0.541	2.60	56%
1:1	692.8	0.534	3.60	69%
1:2	792.8	0.599	8.21	71%