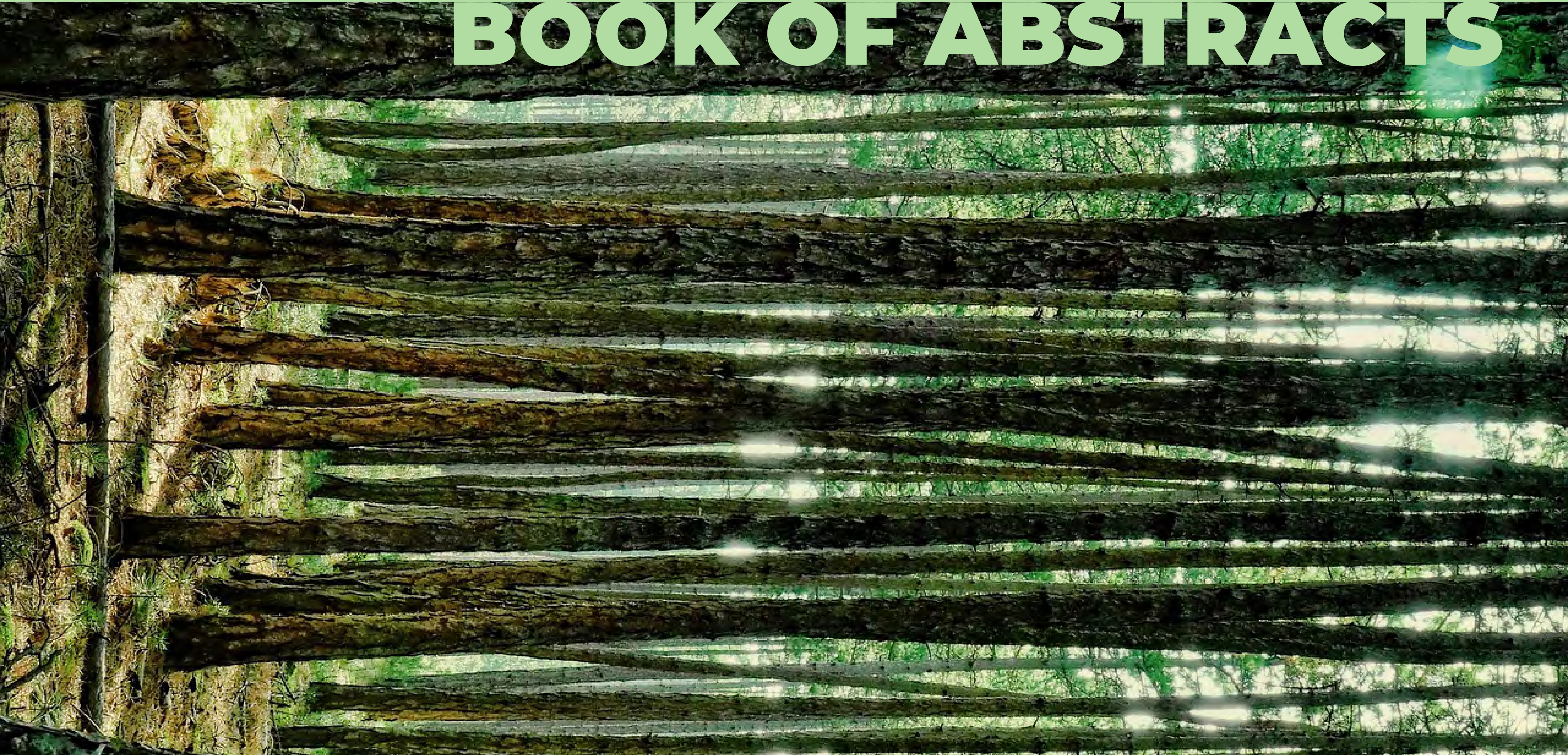
BPS 2025

OCTOBER 1-3, TALLINN, ESTONIA

BOOK OF ABSTRACTS



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23d International Scientific Conference BPS 2025
“Baltic Polymer Symposium 2025”

BOOK OF ABSTRACTS

of Baltic Polymer Symposium 2025
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The abstracts are published as submitted by the authors. The content and language have not been edited or corrected.

Tallinn, Estonia

VENUE

Park Inn by Radisson Meriton Conference & Spa Hotel Tallinn,
Toompuiestee 27

GALA DINNER

F-Hoone restaurant, Telliskivi 60/2

TOUR

Bastion passages, Komandandi street 2

Organizers

Tallinn University of Technology

Viktoria Gudkova

Natalja Savest

Julia Smirnova

Vitali Sõritski

Andres Krumme

Gratitude to our PhD student for helping host and coordinate BPS2025:

Anna Ilnitskaja

Aysha Siddika

Gretel Brus

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Programme

Wednesday, October 1st

16:00-18:00	**REGISTRATION AT WHITE HALL**
17:00-18:00	Opportunity to pin the poster at White Hall
18:00-21:00	**WELCOME PARTY**

Thursday, October 2nd

08:00-09:00	Opportunity to pin the poster at White Hall

Session I Chairman: Prof. Andres Krumme

09:00-09:05	Opening of conference **prof. Andres Krumme** (Tallinn University of Technology)
09:05-09:15	Introduction from rector of Tallinn University of Technology **Tiit Land**
09:15-09:55	Plenary — **prof. Nicolas Joly** (Unité Transformations & Agroressources) *Polymers from natural resources: The strength of Polysaccharides, raw material platforms for a wide range of applications*
09:55-10:10	Keynote — **Anda Fridrihsone** (Latvian State Institute of Wood Chemistry) *Environmental Assessment of Aza-Michael Donors Based Used Cooking Oil for Reprocessable Thermoset Polymers*
10:10-10:25	Keynote — **associate prof. Andrejs Krauklis** (Latvia University of Life Sciences and Technologies) *A modular materials informatics toolkit for evaluating ageing in composite materials*
10:25-10:35	**Kaspar Uuselu** (University of Tartu) *Designing Lignin Properties for Targeted Use in Bio-Based Functional Materials*
10:35-10:45	**Kristi Parro** (Ministry of Climate) *Taking advantage of wood: policy makers perspective*
10:45-11:15	**COFFE BREAK AND POSTER SESSION**

Session II Chairman: Dr. Vitali Sõritski

11:15-11:55	Plenary — **Dainius Martuzevicius** (Kaunas University of Technology) *Polymer Nanofibres for Filtration, Separation, and Beyond*
11:55-12:10	Keynote — **Illia Krasnou** (Tallinn University of Technology) *Reactive extrusion of long-chain fatty acid cellulose esters for industrial implementation*
12:10-12:25	Keynote — **Livia Matt** (University of Tartu) *Isosorbide-Based Covalent Adaptable Polymethacrylate Networks by Hydrazide Crosslinking*
12:25-12:35	**Hamisu Aliyu Mohammed** (Kaunas University of Technology) *Donor-Tuned Triplet Dynamics: TADF to Hot-Exciton Pathways in Bipolar OLED Emitters*
12:35-12:45	**José Ignacio Delgado** (IMDEA materials) *Manufacturing multilayers for clear aligners with tunable thermomechanical properties*
12:45-14:00	**LUNCH AND POSTER SESSION**

Session III Chairman: Prof. Juozas Vidas Gražulevičius

14:00-14:40	Plenary — **Illia Dobryden** (RISE) *Bio-based and sustainable solutions for energy storage and energy harvesting*
14:40-14:55	Keynote — **prof. Marc Jean Médard Abadie** (Institute Charles Gerhardt Montpellier ICGM) *Spotlight on Green: Green Climate & Ecological transition, Green Chemistry in Polymer Science, Environmentally Friendly Processing & Recyclability. Myth or Reality?*
14:55-15:10	Keynote — **Mikelis Kirpluks** (Latvian State Institute Of Wood Chemistry) *Design and Characterisation of Bio-Based β-Amino Polyester Resins with Reprocessable Thermoset Behaviour*
15:10-15:20	**Francisco Tienda Resendez** (Tallinn University of Technology) *Towards Safe and Sustainable Building: Reclaimed Timber for Structural Use*
15:20-15:30	**Henrique Sepulveda Del Rio Hamacek** (Tallinn University of Technology) *Production and characterization of an exopolysaccharide from an oleaginous yeast*
15:30-16:00	**COFFE BREAK AND POSTER SESSION**

Session IV Chairman: Prof. Ricardas Makuska

16:00-16:40 Plenary — **Janis Rizikovs** (Latvian State Institute of Wood Chemistry)

Versatile roles of birch bark suberinic acids: from wood adhesives to polymer building blocks

16:40-16:55 Keynote — **prof. Remo Merijs-Meri** (Riga Technical University)

Characterisation of thermoplastic starch composites with bio-based additives for foaming applications

16:55-17:10 Keynote — **Ritvars Bērziņš** (Riga Technical University)

Synthesis and properties of one component cardanol-type renewable material use in sealant industry

17:10-17:20 **Mahendra Kothottil Mohan** (Tallinn University of Technology)

Lignin Valorization via Chloromethylation as a Versatile Approach Towards Sustainable Materials

17:20-17:30 **Sharib Khan** (Estonian University of Life Sciences)

We can make anything from the lignin and money!

19:00-00:00 **GALA DINNER**

Friday, October 3rd

Session V Chairman: Prof. Remo Merijs-Meri

09:00-09:40 Plenary — **prof. Arthur Ragauskas** (University of Tennessee)

Acquiring new value from the forests

09:40-09:55 Keynote — **prof. Sergejs Gaidukovs** (Riga Technical university)

Lignocellulose-Based Biocomposites and 3D-Printed Bio-Resins

09:55-10:10 Keynote — **Svetlana Butylina** (LAB University of Applied Sciences)

Effect of Xylan Extract on properties of Physically Crosslinked Xylan/Poly(vinyl alcohol) Composite Hydrogels

10:10-10:20 **Tanuj Kattamanchi** (Tallinn University of Technology)

Effect of Drying Methods on the Morphological and Functional Properties of Cellulose Ester Films

10:20-10:30 **Tolgay Akkurt** (Tallinn University of Technology)

Valorizing Low-Quality Wood Species into Innovative Multilayer Engineered Wood Products

10:30-10:40 **Kait Puss** (University of Tartu)

Unlocking the Potential of Lignin-Cellulose Mixture: A New Pathway to Sustainable Biomaterials

10:40-11:10 **COFFE BREAK AND POSTER SESSION**

Session VI Chairman: Prof. Sergejs Gaidukovs

11:10-11:50 Plenary — **prof. Oleh Kabat** (Ukraine University of Science and Technologies)

Scientific and technical basis of a resource-saving method of processing thermo-resistant polymer composites for tribotechnical purposes

11:50-12:05 Keynote — **Ayodeji Emmanuel Amobonye** (Kaunas University of Technology)

Functional characterization of acetylated-, succinylated- , and dual-modified potato peel starches

12:05-12:15 **Arnis Abolins** (Latvian State Institute of Wood Chemistry)

Valorization of Used Cooking Oil into Aza-Michael Donors for Reprocessable Thermoset Polymers

12:15-12:25 **Elina Vindedze** (AM Craft)

Fire-retardant and Tribological Properties of Painted Ultem 9085 Polymer Samples Processed by Fused Deposition Modelling

12:25-12:35 Sponsor talk — **Andres Siiman** (Syntpot OÜ)

Infrared microscopy for polymer analysis

12:35-12:40 **Viktoria Gudkova** (TalTech Wood Valorisation HUB)

TalTech Wood Valorisation HUB

12:40-12:50 Final Word **prof. Andres Krumme** (Tallinn University of Technology)

12:50-14:00 **LUNCH**

15:00-16:30 **TOUR TO THE BASTION PASSAGES**

Contents

PLENARY SESSIONS

ORAL PRESENTATIONS

POSTERS

Plenary sessions

POLYMERS FROM NATURAL RESOURCES: THE STRENGTH OF POLYSACCHARIDES, RAW MATERIAL PLATFORMS FOR A WIDE RANGE OF APPLICATIONS

Nicolas Joly

Unité Transformations & Agroressources, France

One of the major challenges, concerning polysaccharides and their derivatives, is to replace petroleum-based polymers in innovative, diversified and niche applications, as a main material or as an additive, especially in construction, packaging materials, agrochemicals and health.

For more than two decades, our research team has been working in this direction, trying to find a way to convert these carbohydrate-based polymers into plastic materials, functional additives for the adjunction of organic or inorganic matrices, biosourced active ingredients.

Thus, our achievements, involving polysaccharides such as cellulose, hemicelluloses, inulin, chitosan and starch, their modification and their uses as high- or low-added value products, will pe presented.

We will talk about starch derivatives as superplasticizing additives for concrete, inulin derivatives as vector of active ingredients for pet food, chitosan as an antifungal agent and biopesticide in agrochemistry, of hemicelluloses, starch, chitosan, inulin and cellulose derivatives as plastics and/or additives for bioplastics. Prospects for new applications will also be presented through our current actions.

Kewords: polymers, natural resources, polysaccharides

POLYMER NANOFIBRES FOR FILTRATION, SEPARATION, AND BEYOND

Dainius Martuzevicius

Kaunas University of Technology, Lithuania

Polymer nanofibres offer broad opportunities for multiple sectors, including process engineering (filtration, separation), and biomedical engineering (artificial tissues and scaffolding) due to their high specific surface area, tunable surface chemistry, and versatile manufacturing pathways. Electrospinning, a key technology for nanofibre fabrication, enables precise control over fibre diameter and morphology through the manipulation of polymer rheology, solvent volatility, and electrical field dynamics. This presentation systematically explores recent advancements made by our group, highlighting distinct research campaigns unified by electrospinning technology.

Initially, we discuss aerosol filtration using bio-based polymer composite nanofibres designed for efficient particle capture. Novel fibre architectures, including deterministic 3D-printed and melt/solution-electrospun hybrid substrates, demonstrate optimized flow-resistance profiles surpassing conventional filtration media. Cellulose-based nanofibres electrospun from ionic liquids are presented, emphasizing the interplay between processing conditions, crystallinity, and mechanical robustness for tissue engineering and structural composites. Extending beyond traditional filtration we report on functional nanofibre composites incorporating graphene oxide, ZnO, and TiO_2 for selective adsorption and photocatalytic degradation processes.

The biomedical segment introduces functionalized electrospun scaffolds that regulate cell behavior through physical and chemical cues. Multi-layered architectures loaded with bioactive factors exhibit enhanced in-vitro and in-vivo performance, for modelling cartilage regeneration, tumours and multiple more.

Kewords: polymer nanofibres, electrospinning, aerosol filtration, tissue-engineering scaffolds, photocatalytic degradation

BIO-BASED AND SUSTAINABLE SOLUTIONS FOR ENERGY STORAGE AND ENERGY HARVESTING

Illia Dobryden

Division of Sustainable Materials and Packaging, RISE Research Institutes of Sweden, Malvinas väg 3, SE-114 86, Stockholm

The development and integration of bio-based and sustainable materials into energy storage, i.e. batteries, and harvesting systems are increasingly recognized as essential for addressing the combined challenges of environmental sustainability, resource depletion, and the significantly growing global demand for energy. The development of lithium-ion battery (LiB) and sodium-ion battery (SiB) production is rapidly evolving with many gigawatt factories, i.e. large-scale manufacturing facilities for batteries, built worldwide. This process is driven by significantly growing demand for energy storage in electric vehicles (EVs), grid applications, and portable electronics. At the same time, it creates a large market, and volume demands for battery production materials, such as active materials, binders, separators, electrolytes, etc. Binders are essential components in both the anode and cathode manufacturing for LiBs and SiBs. Their primary function is to provide the mechanical integrity of the electrode and good electrochemical performance and stability during battery cycling. Currently used industrial binders, such as polyvinylidene fluoride (PVDF), styrene-butadiene rubber (SBR) and carboxymethyl cellulose (CMC) have several, environmental, sustainability and technical limitations due to regulatory restrictions in EU, usage of toxic solvents, such as N-methyl-2-pyrrolidone (NMP) for PVDF, and end-of-life recycling difficulties. Current developments of bio-based binders are focused on addressing such environmental concerns in battery manufacturing and recycling [1]. Moreover, bio-based binders are suitable for fully water-based processing and removing the need of NMP usage at industrial scale. Our current research is focusing on implementing and valorising wood and agriculture derived solutions, such as nanocellulose, lignin, and starch.

Another emerging and interesting area is energy harvesting utilizing sustainable solutions. Energy harvesting based on triboelectric, i.e. electrical charge generated through frictional contact between two materials, and piezoelectric, i.e. electric charge generated due to mechanical stress and deformation, effects in biopolymers and cellulose derivatives offers a promising avenue for sustainable and self-powered electronics. Unlike large-scale solar and wind energy sourcing, these mechanisms can directly convert mechanical energy from human motion, material compression\stretching and vibrations into electricity. This enables low-power and self-powered applications in wearables, smart textiles, biomedical sensors, and other IoT devices. Moreover, such materials possess improved biodegradability, mechanical flexibility, and biocompatibility with a good potential for scaling their manufacturing.

Kewords: energy, bio-based, binders, batteries, triboelectric, piezoelectric

References:

1. *Dobryden, I.; Montanari, C.; Bhattacharjya, D.; Aydin, J.; Ahniyaz, A.* Bio-Based Binder Development for Lithium-Ion Batteries. Materials 2023, 16, 5553.

VERSATILE ROLES OF BIRCH BARK SUBERINIC ACIDS: FROM WOOD ADHESIVES TO POLYMER BUILDING BLOCKS

Janis Rizikovs, Aigars Paze, Daniela Godina, Rudolfs Berzins, Guntis Sosins, Arnis Abolins, Aiga Ivdre

Latvian State Institute Of Wood Chemistry, Latvia

The widespread use of synthetic binders and polymers in composite materials presents serious health concerns, as they can release hazardous volatile compounds throughout production and end-use phase. Due to the unique structure of birch bark suberinic acids (SA), there is a high potential as an alternative to replace synthetic binders and polymers. Besides veneer, there are other industries, such as the furniture and cellulose industry, which has a large amount of residual birch bark combusted for energy needs. Birch outer bark contains up to 45% of suberin - a lipophilic macromolecule that occurs in the cell walls of the outer layer of several plants, performing the protective function of the plant/tree from the conditions of the surrounding environment and pests.

The valorization of birch outer bark—a currently underutilized industrial by-product—is gaining momentum as a sustainable strategy for developing bio-based adhesives and polymers. Our research presents recent advances in the extraction, characterization, and application of SA obtained from birch (Betula pendula and Betula pubescens) outer bark. Through controlled alkaline depolymerization, a complex mixture of C18 diacids, hydroxyacids, and other suberin-derived molecules can be isolated and utilized directly or processed into bio-polyols for rigid polyurethane (PU) synthesis.

In adhesive applications, SA-based binders demonstrated strong performance in particleboards and plywood, meeting European standards for mechanical strength and moisture resistance without requiring synthetic resins. Simultaneously, SA-derived polyols were evaluated as renewable PU precursors, overcoming processing challenges such as high viscosity and acidic content through tailored fractionation and formulation strategies.

Beyond adhesives and polyols, SA also offer potential as wood protection agent through impregnation and coating, additives in wood–polymer composites and 3D printing inks, enhancing interfacial compatibility, water resistance, and material durability. These findings highlight the multifunctionality of birch bark-derived SA as a circular, non-food biomass feedstock for innovative materials with reduced environmental impact.

Kewords: suberinic acids, birch bark, bio-based adhesives, polyurethanes, polyols, sustainable materials, wood composites

Aknowledgements: This research was funded by European Regional Development Fund project no. 1.1.1.3/1/24/A/040 "Upcycling of extracted birch outer bark into innovative bio-based polyol suitable for industrial application of rigid polyurethane insulation foam (SAMPUR)".

ACQUIRING NEW VALUE FROM THE FORESTS

Arthur Ragauskas

University of Tennessee, Knoxville, USA

The biorefining of bioresources has evolved over the past two decades from primarily focused on cellulosic ethanol to addressing the challenge of atomic economy whereby the biopolymers of the plant cell wall are efficiently fractionated for fuels, chemicals, materials and power. From this perspective, the challenges of lignin valorization have rapidly evolved with lignin first pretreatments taking a dominant research priority. An overarching hypothesis to lignin first pretreatments is that the matching of amphiphilic characteristics of solvents with those of biomass drives the dissociation of their component molecules resulting in structural disruption of these complex biomaterials. Our studies have focused on reducing the recalcitrance of biomass and utilization of the non-cellulosics components for materials and chemical applications. In this seminar we will discuss our efforts in lignin #D printed composites, vitrimers, polyurethanes, and carbon fibers. In closing, we will examine where future research efforts are directed.

Kewords: biomass fractionation, lignin valorization

Aknowledgements: University of Tennessee.

References:

1. *Zhang, Shuyang; Ji, Anqi; Meng, Xianzhi; Bhagia, Samarthya; Yoo, Chang Geun; Harper, David P.; Zhao, Xianhui; Ragauskas, Arthur J.* Structure-property relationship between lignin structures and properties of 3D-printed lignin composites. Composites Science and Technology (2024), 249, 110487. (doi.org/10.1016/j.compscitech.2024.110487)

SCIENTIFIC AND TECHNICAL BASIS OF A RESOURCE-SAVING METHOD OF PROCESSING THERMO-RESISTANT POLYMER COMPOSITES FOR TRIBOTECHNICAL PURPOSES

Oleh Kabat, Oleh Chervakov, Volodymyr Sytar

University of Science and Technologies, Ukraine

Intensive development of modern society is practically impossible without progress in such industries as electric power, chemical and petrochemical, metallurgical, machine building, etc. Moreover, recently, the main driving force of industrial development has been the electric power industry (production of modern machines and mechanisms for obtaining energy from renewable and nuclear sources of resources) and the machine-building industry in the field of production of aviation, rocket and space technology, robots, etc.

Among the most recent achievements in these industries are the “Solar Impulse SI2” solar-powered aircraft, the “Space Ship Two” supersonic suborbital aircraft; suborbital, orbital and reusable spacecraft “Falcon 9”, “Falcon heavy”, “Dragon”; electric vehicles with a range of up to 1,000 km, etc.

A common feature of these machines is that their components and parts operate under fairly harsh operating conditions with high levels of loads, sliding speeds, temperatures, exposure to abrasive or aggressive environments, etc., for a long time. And therefore, one of the main problems in their development and implementation is the difficulty of ensuring a high level of reliability and durability in operation.

One of the main ways to solve the problem of increasing the reliability and durability of modern machines and mechanisms is to use new structural materials for the manufacture of the main elements of modern machines, which have a better level of properties compared to those already in use. The creation of such materials in accordance with the principles developed by the European Commission on Key Enabling Technologies (KETs) is one of the most priority and relevant tasks today.

In modern machines and mechanisms, metals and their alloys, ceramics, polymers and polymer composites (PC), wood, glass, etc. are used as structural materials. The most promising of them are polymers and PC, as evidenced by the increase in their consumption by all industries, which recently significantly exceeds other materials.

Existing PCs produced on an industrial scale can no longer fully ensure the normal operation of machines due to insufficient thermal stability, strength, and tribological properties.

Their laboratory analogues, the level of properties of which meets the requirements for parts of modern machines, have a rather high cost due to the scarcity of starting components and the complex technology of processing into products.

Therefore, an urgent scientific and technical task is to develop new technologies for creating materials based on polymers with a high level of thermophysical, physicomechanical and tribological properties and low cost through the use of non-scarce starting components and simplification of the processing technology into products.

The work theoretically substantiates and develops a new resource-saving method for manufacturing heat-resistant PCs based on aromatic polyamide, polytetrafluoroethylene and diphenylsulfone formaldehyde oligomer with a dispersed filler - silica gel - evenly distributed in their volume. This is achieved by combining (in situ) finely dispersed particles of the starting polymers with a filler during the process of synthesizing silica gel from an aqueous solution of sodium silicate. The proposed method allows to abandon the operation of mechanical mixing of the initial components of polymer compositions at the preparatory stage of processing, which significantly simplifies and reduces the cost of manufacturing parts from the developed PCs and contributes to obtaining polymer compositions with high quality distribution of the initial components.

Systematic studies have been conducted to assess the influence of PC compositions and their processing technologies on the thermophysical, physicomechanical and tribological properties of products made from them. It has been established that the use of the developed method allows obtaining PCs with a 10-25% improvement in the level of the studied properties [1,2]. The compositions of the developed PCs have been optimized from the point of view of tribological properties [3].

Recommendations have been developed for the introduction of parts from the created PCs into industry [4]. Their industrial research has been carried out at chemical and agricultural enterprises (LLC "T CORP GROUP", LLC "KODATSKE-AGRO", NPP "SOYUZ-KOMPOZYT", LLC "KHIMPOSTACH DNIPRO", LLC "INTER AVIA INVEST").

Kewords: thermo-resistant polymer, aromatic polyamide, ptfe, phenolic oligomer, resource-saving method of processing, thermophysical, physicomechanical and tribological properties

References:

1. *Kabat, O., Makarenko, D., Derkach, O., Muranov, Y.* Determining the influence of the filler on the properties of structural thermal-resistant polymeric materials based on phenylone C1 // Eastern-European Journal of Enterprise Technologies. (2021).
2. *Kabat, O., Sytar, V., Derkach, O., Sukhyy, K.* Polymeric composite materials of tribotechnical purpose with a high level of physical, mechanical and thermal properties // Chemistry & Chemical Technology. (2021).
3. *Kabat, O., Girin, O., Heti, K.* Polymer composites based on aromatic polyamide and fillers of spherical and layered structure for friction units of high-performance equipment // Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications. (2023).
4. *Kabat, O., Bannyk, N., Voronyi, O.* Polymer composite materials of special purpose for the aerospace and rocket industry // Science and innovation. (2025).

Oral presentations

ENVIRONMENTAL ASSESSMENT OF AZA-MICHAEL DONORS BASED USED COOKING OIL FOR REPROCESSABLE THERMOSET POLYMERS

Anda Fridrihsone, Arnis Āboliņš, Miķelis Kirpļuks

Latvian State Institute of Wood Chemistry, Latvia

For Europe to meet the targets set by the Green Deal and get closer to climate neutrality in 2050, polymers made from renewable raw materials must be developed while making sure the material can be recycled at the end of its life cycle. The goal of the TReResin project is to develop a new type of thermosetting resin with almost 100% renewable raw material content, which can be recycled by changing the chemical conformation of the polymer due to the thermally reversible reactions of β-amino polyesters. Within the project, Aza-Michael components, donor and acceptor, will be synthesized from used cooking oil (UCO). UCO is a waste without nutritional value generated in food processing industries, restaurants, and households. UCO is a combination of triglycerides and free fatty acids that have undergone physicochemical changes during food preparation (high temperature, moisture).

Early in the development stage, life cycle assessment (LCA) might be useful, especially for chemical processes, in determining hotspots, evaluating potential environmental effects, comparing alternatives, choosing manufacturing routes, and refining the processes themselves. The aim of the study was to evaluate the environmental impact of UCO-based Aza-Michael donors developed at the Latvian State Institute of Wood Chemistry suitable for the development of bio-based vitrimer resins. The synthesis technology currently is at TRL 2. The chosen system boundary was cradle-to-(laboratory) gate. The production system for Aza-Michael donors included feedstock production, required energy, and other chemicals needed for the synthesis process. The LCA model was built according to the ISO 14040/44:2006 series. LCA analysis was performed using SimaPro 9.6 software by Pré Consultants. Potential environmental impacts were assessed according to ReCiPe's (2016) v1.1 midpoint method, and global warming potential (GWP) was assessed using the Intergovernmental Panel on Climate Change (IPCC), 2021 GWP 100a' method. For the first time, the environmental impact of a lab-scale bio-based vitrimer component synthesis is investigated, hot spots are identified, and routes for improvement are explored. Primary data for the life cycle inventory were gathered from the experiments in the laboratory which is an advantage and best-case scenario. However, because background data quality and availability are limited, the LCA also brought to light the difficulties in conducting LCA on novel chemical synthesis pathways.

Kewords: bio-based, vitrimers, life cycle assessment, circular economy

Aknowledgements: This research was funded by the Latvian Council of Science, project "Bio-based, Highly Crosslinked β-Amino Polymer Resins as Thermally Recyclable Building Blocks (TReResin)", project No. lzp-2024/1-0333.

A MODULAR MATERIALS INFORMATICS TOOLKIT FOR EVALUATING AGEING IN COMPOSITE MATERIALS

Andrejs Kraukliss

Latvia University of Life Sciences and Technologies, Faculty of Forest and Environmental Sciences, Institute of Civil Engineering and Woodworking, MEI Core Group, Akadēmijas Street 19, Jelgava, LV-3001, Latvia

Composite materials undergo deterioration due to environmental influences such as moisture ingress, temperature variations, mechanical loading, and chemical exposure, which collectively degrade their mechanical integrity and undermine structural dependability. To tackle this issue, an enhanced modular materials informatics framework is proposed. This method synergistically combines Quantitative Structure-Property Relationship (QSPR) modelling, Machine Learning (ML), mechanical testing, and Non-Destructive Evaluation (NDE) methods – specifically Fourier Transform Infrared (FT-IR) spectroscopy and Inductively Coupled Plasma (ICP) mass spectrometry – to enable precise prediction of composite material ageing [1-3]. The framework operates across multiple scales, connecting molecular-level degradation to macroscopic engineering impacts. FT-IR spectroscopy is utilized to monitor molecular-scale degradation phenomena, such as hydrolysis, diffusion, and chemical reactions, furnishing vital insights for forecasting changes in mechanical properties like stiffness and strength. The inherently modular and multiscale design of this framework allows for its systematic extension to capture the diverse ageing responses of the composite's constituents: the matrix, fibres, and interphase regions. By integrating molecular degradation mechanisms with transport phenomena and leveraging advanced computational tools, this approach yields detailed and accurate lifetime predictions. Separately analysing each composite component's interaction with environmental stressors improves the prediction reliability. The methodology incorporates molecular-level mechanisms, diffusion effects, and sophisticated numerical simulations – including finite element analysis (FEA) and multiscale modelling techniques – to pinpoint critical failure points and generate comprehensive durability forecasts. Experimental validations reveal a strong agreement between model predictions and observed ageing behaviours under various environmental exposures. This framework advances the fundamental understanding of composite degradation, supporting more effective structural health monitoring while mitigating the need for extensive and costly experimental campaigns. This novel informatics-driven approach enhances predictive accuracy and understanding of composite ageing phenomena. Its adoption facilitates proactive maintenance scheduling and structural health management, ultimately extending service life and promoting safer, more sustainable utilization of composite materials. Thus, this methodology holds significant potential benefits for both industrial applications and academic research by enabling reliable long-term performance assessments across diverse composite material systems.

Kewords: composites, modelling, durability

Aknowledgements: This work has been supported by F-TEN4.

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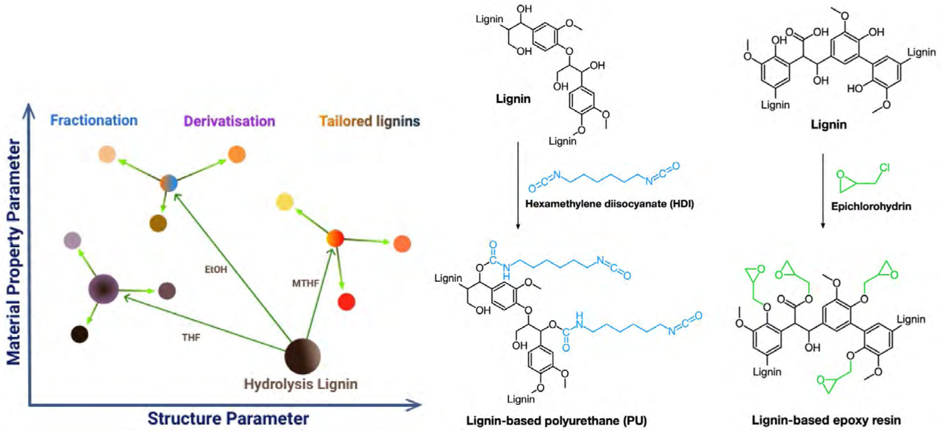
1. *Krauklis, A.E. Verceux, F., Grammatikos, S.* Rapid Non-Destructive Polymer Degradation Degree Evaluation Method Using Quantitative Structure-Property Relationship. Mechanics of Composite Materials. (2025).
2. *Krauklis, A.E. Verceux, F., Grammatikos, S.* Quantitative Structure-Property Relationships for Non-Destructive Evaluation of Aging in Polymers," In: Proceedings of the 83rd International Scientific Conference of the University of Latvia (Eds.: Glaskova-Kuzmina T.), Riga, Latvia. (2025).
3. *Krauklis, A.E.* Environmental Aging of Constituent Materials in Fiber-Reinforced Polymer Composites. Norwegian University of Science and Technology, Trondheim, Norway. (2019).

DESIGNING LIGNIN PROPERTIES FOR TARGETED USE IN BIO-BASED FUNCTIONAL MATERIALS

Kaspar Uuselu[1], Siim Salmar[2]

[1]University of Tartu, Institute of Chemistry, Wood Chemistry and Lignin Laboratory, Estonia
[2]University of Tartu, Estonia

Among the products derived from wood biorefining, hydrolysis lignin (HL) is potentially the most valuable. Our research group approach focuses on material properties present in lignin while increasing reactivity for use in lignin-based polymer applications as an alternative to fossil fuel derived synthetic materials. Challenges with lignin structure reactivity relationships are addressed using in-house solvent fractionation techniques.1 This allows us to further develop property specific materials for targeted use.



HL-based materials under research are derived using polyurethane and epoxy chemistry as well as epoxide-derived non-isocyanide polyurethanes (NIPUs). Reagents for these chemical modifications all have a potential to be bioderived. Valorisation of HL into bio-based functional materials offers both economic and environmental benefit for the wood-based biorefinery industry.

Kewords: hydrolysis lignin, polymer chemistry, solvent fractionation, sustainable materials

Aknowledgements: This work was co-funded by the European Union and the Ministry of Education and Research via project TEM-TA85.

References:

1. *Vider, H.; Treiberg, N.; Puss, K.K.; Loog, M.; Salmar, S.* Fractionation of Lignin with Aqueous Organic Solvents: A Step Closer to Sustainable Wood Biorefinery. ChemRxiv. 2025.
2. *Riddell, L. A.; Enthoven, F. J. P. A.; Lindner, J.-P. B.; Meirer, F.; Bruijnincx, P. C. A.* Expanding Lignin Thermal Property Space by Fractionation and Covalent Modification. Green Chem. 2023, 25 (15), 6051–6056.

REACTIVE EXTRUSION OF LONG-CHAIN FATTY ACID CELLULOSE ESTERS FOR INDUSTRIAL IMPLEMENTATION

Illia Krasnou, Andres Krumme

Taltech, Biopolymer Technology Laboratory, Estonia

The industrial production of long-chain fatty acid cellulose esters (LCFA-CEs), valued for their thermoplasticity and controllable biodegradability. But it has traditionally been hindered by inefficient, multi-step batch processes that consume a large volume of different solvents. This presentation will demonstrate how reactive extrusion (REX) provides a transformative, continuous manufacturing platform. The platform has advanced scalability and economic potential. By integrating synthesis, mixing, and devolatilization into a single twin-screw extruder, REX drastically reduces reaction times from hours to minutes, minimizes or eliminates solvent use, and ensures superior product uniformity through intense thermomechanical mixing. We will highlight how these technical advantages translate into compelling industrial benefits, including reduced capital and operating expenses, enhanced process safety, and a smaller environmental footprint. Thus, REX is not just an alternative but a pivotal technology for the efficient and sustainable industrial implementation of LCFA-CE production.

Kewords: reactive extrusion, cellulose fatty acid ester, bio-polymer, green chemistry

Aknowledgements: TEM-TA103 project.

ISOSORBIDE-BASED COVALENT ADAPTABLE POLYMETHACRYLATE NETWORKS BY HYDRAZIDE CROSSLINKING

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Intensely growing environmental concerns have driven academia and industry towards renewable feedstocks, such as lignocellulosic biomass, to find alternatives to fossil-based chemicals and materials in everyday life. At present, it is especially challenging to develop biobased thermoplastics with high glass transition temperatures (T_g > 100°C) as the availability of suitable rigid building blocks from biomass is limited.

One strategy to enhance the properties of biobased plastic (e.g., hardness, T_g, thermal stability, solvent resistance) is to transform a thermoplastic polymer into a thermoset by connecting the linear polymer chains via dynamic multifunctional crosslinkers. Such dynamic covalent networks (also, covalent adaptable networks) [1], can provide chemical stability and mechanical strength equal to non-dynamic crosslinked polymer networks.

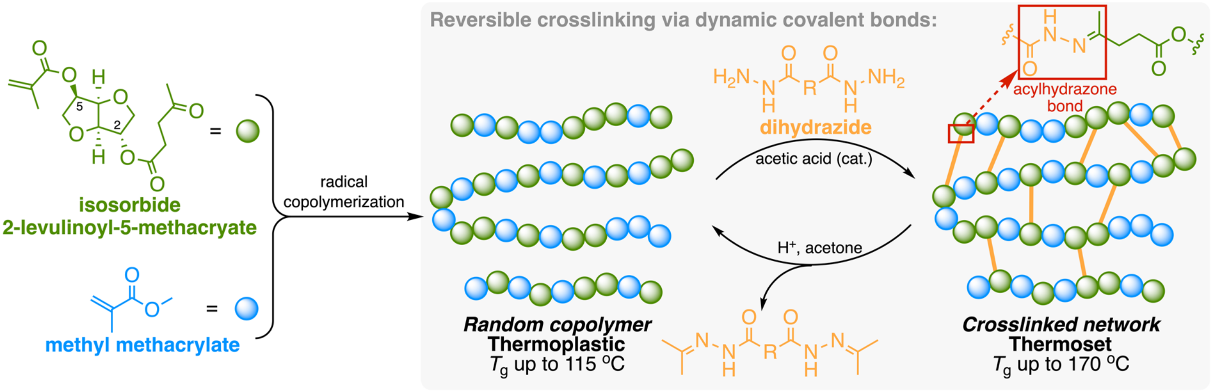

Figure 1. Reversible crosslinking of isosorbide-based polymethacrylates.

In this work, we have regioselectively functionalized biobased isosorbide with methacrylate [2] and levulinoyl side chains [3], and then prepared corresponding random copolymers with methyl methacrylate. These polymers enabled us to investigate the reversible crosslinking feature through the formation of dynamic covalent bonds (specifically, acylhydrazone bonds) between the pendant ketone groups in the levulinoyl side chain and dihydrazides as crosslinking agents. Subsequently, the removal of the crosslinking unit and a following re-crosslinking with dihydrazide were also demonstrated. Thus, the reversibility of dynamic bonds allows an interesting chemical recycling route for such biobased polymer networks.

Kewords: isosorbide, polymethacrylate, dynamic covalent bond, covalent adaptable network, biobased polymer

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DONOR-TUNED TRIPLET DYNAMICS: TADF TO HOT-EXCITON PATHWAYS IN BIPOLAR OLED EMITTERS

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Efficient harvesting of triplet excitons is essential for maximizing internal quantum efficiency in organic light-emitting diodes (OLEDs), as it enables utilization of both singlet and triplet populations and thus markedly improves device performance. Here we compare the properties of three dibenzo[a,c]imidazophenazine (DBIPO)-derived emitters that access distinct triplet-harvesting regimes through selective donor identity and steric design. The DBIPO derivative bearing 5H-dibenzo[b,f]azepine donor (EHBIPOAz) exhibits hybridized local and charge-transfer (HLCT) character with minimal vibrational reorganization ($\lambda \approx 0.084$ eV), narrow emission, high photoluminescence quantum yields (PLQY ≈ 75% in solution; ≈ 92% in Zeonex), and ultrafast hot-exciton reverse intersystem crossing (khRISC $\geq 10^{11}$ s^{-1}). By contrast, DBIPO derivatives bearing tert-butyl-acridine and phenothiazine donors (EHBIPOAc and EHBIPOPh, respectively) show predominantly intramolecular charge-transfer emission. EHBIPOAc displays a very small singlet–triplet gap (ΔEST ≈ 0.08 eV) consistent with efficient thermally activated delay fluorescence (TADF) and rapid reverse intersystem crossing, whereas EHBIPOPh shows a larger ΔEST (≈ 0.45 eV) with pronounced delayed emission behavior. All materials demonstrate bipolar charge mobilities $>10^{-3}$ cm^2 V^{-1} s^{-1} at high electric fields and, when incorporated into devices, achieve peak external quantum efficiencies of 25.5% (EHBIPOAc) and 28.7% (EHBIPOPh), while a hyperfluorescent OLED employing EHBIPOAz achieves 23.4% EQE (sky-blue). The combined photophysical, electrochemical, and thermal characteristics (Td5% > 440 °C; HOMO ≈ 5.1–5.5 eV; LUMO ≈ 3.0–3.1 eV) demonstrate that targeted donor and steric modifications can selectively realize HLCT, TADF, or hot-exciton pathways, enabling high color purity, rapid emission kinetics, and outstanding OLED performance.

Kewords: hlct, hot-exciton (hrisc), tadf, reorganization energy, bipolar charge transport, oleds

SPOTLIGHT ON GREEN: GREEN CLIMATE & ECOLOGICAL TRANSITION, GREEN CHEMISTRY IN POLYMER SCIENCE, ENVIRONMENTALLY FRIENDLY PROCESSING & RECYCLABILITY. MYTH OR REALITY?

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The global climate crisis and environmental degradation have made "green" a buzzword across industries. But is the push toward eco-friendly materials and processes in polymer science truly impactful - or is it more marketing than meaningful change?

The intersection of green chemistry, climate-conscious innovation, and polymer science is a hotbed of both promise and skepticism. This theme aims to explore whether the "green" label in polymer research and industrial processing is a genuine stride toward sustainability or merely a fashionable myth. With increasing environmental concerns, circular economy goals, and policy pressure, the scientific community must critically assess the impact, limitations, and feasibility of so-called green solutions.

However while strides in green polymer science are real, they often face hurdles in scalability, economic viability, and actual environmental benefit. This spotlight seeks to cut through the buzzwords to examine what’s myth and what’s meaningful progress.

We will deal successively with CO2 phobia and global warning, Ecological transition, Green chemistry principles in polymer science, Eco-friendly additives, Eco-friendly processing technologies and Recyclability EoL

“Are we truly building a sustainable polymer future, or just painting plastics green?”

Kewords: global warning, ecological transition, green chemistry principles in polymer science, eco-friendly additives, eco-friendly processing technologies and recyclability eol

DESIGN AND CHARACTERISATION OF BIO-BASED Β-AMINO POLYESTER RESINS WITH REPROCESSABLE THERMOSET BEHAVIOUR

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Latvian State Institute Of Wood Chemistry, Latvia

The European Commission has outlined an ambitious path toward sustainable growth through initiatives such as the European Green Deal and Circular Economy Action Plan, with the overarching goal of achieving climate neutrality by 2050. Despite this, the development of sustainable and circular solutions for polymer materials remains a substantial challenge. One of the key priorities is to reduce reliance on fossil-derived resources while advancing innovations that minimise waste, enhance recyclability, and eliminate landfill disposal.

Vitrimers—a new class of polymer materials—offer a promising approach by integrating the robustness of thermosets with the reprocessability of thermoplastics, made possible by dynamic covalent crosslinks. This study focuses on the development of a bio-based β-amino polyester resin featuring covalently adaptable networks, synthesised from renewable feedstocks. Priamine™ 1074, a fully bio-based diamine produced by Cargill, was reacted with a soybean oil-derived acrylate to formulate the vitrimer resin. For comparative analysis, tetraethyl tetramine was also employed as an Aza-Michael donor with three acrylates of differing functionalities: butanediacrylate, trimethylolpropane triacrylate, and pentaerythritol tetraacrylate. The acrylate functionality significantly influenced the crosslinking density of the resulting polymer network.

The chemical structure of the synthesised β-amino polyester resins was confirmed via FTIR spectroscopy, and their thermal behaviour was examined using DSC, TGA, and DMA techniques. Tensile testing was conducted to assess the influence of crosslinking density on mechanical performance. Recyclability was validated through up to three hot-press processing cycles, followed by evaluation of property retention. The results highlight the potential of these bio-based β-amino polyester resins as recyclable adhesives for fibreboard applications in the furniture sector, supporting the transition toward a circular and sustainable material economy.

Kewords: biobased vitrimers, thermoset resins, circular economy

Aknowledgements: The project 101157840 — Polymers-5B — HORIZON-JU-CBE-2023 is funded by the European Union and supported by the Circular Bio-based Europe Joint Undertaking and its members.

TOWARDS SAFE AND SUSTAINABLE BUILDING: RECLAIMED TIMBER FOR STRUCTURAL USE

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The construction sector is increasingly exploring sustainable material strategies to reduce environmental impact and support circular economy goals. Reclaimed timber, sourced from construction, demolition, and manufacturing waste streams, offers significant potential as a renewable building material. This presentation examines the current applications of reclaimed timber in construction, including its use in partition and external walls, loadbearing structures, and cladding. Despite its advantages, widespread adoption faces key challenges related to business models and technical assurance, particularly concerning the material's structural integrity and safety. To address these issues, our research focuses on developing non-destructive methods for assessing the mechanical condition of reclaimed timber. These approaches aim to enable reliable grading and classification, ensuring safe and efficient reuse in new construction projects. The presentation will highlight both the opportunities and the barriers in implementing reclaimed timber and outline pathways for integrating it more effectively into mainstream construction practices.

Kewords: reclaimed timber, circular economy, timber grading, loadbearing, mechanical characterization

Aknowledgements: Certain examples featured in this presentation are derived from the work of OMTRE AS and are included to illustrate practical applications. The ongoing research and results discussed are part of projects co-funded by the European Union’s Horizon Europe programme under the DRASTIC project (Grant Agreement No. 101123330), the European Union and the Estonian Research Council via project TEM-TA080, and the European Innovation Council under the Pathfinder Challenge project RAW (Project No. 101161441).

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PRODUCTION AND CHARACTERIZATION OF AN EXOPOLYSACCHARIDE FROM AN OLEAGINOUS YEAST

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The oleaginous yeast Rhodotorula toruloides is a natural producer of lipids and carotenoids. However, its potential as a producer of extracellular biopolymers remains unexplored. Hence, we aimed to evaluate the R. toruloides CCT0783 for extracellular biopolymer production. We found that the carbon-to-nitrogen ratio influenced exopolysaccharide (EPS) production, reaching 5.84 ± 0.45 g/L under glucose-rich conditions. We characterized the crude biopolymer using FTIR and GC-MS, identifying polysaccharide peaks, wherein EPS consisted of (%) glucose (88.83 ± 4.87), galactose (5.50 ± 1.50), mannose (4.80 ± 1.57), and xylose and arabinose (0.87 ± 0.04) monomers. The dried EPS also contained a fractional presence of protein (1.0%). Interestingly, inorganic, but not organic, nitrogen metabolism was associated with the acidification of the culture environment and simultaneous EPS production. A comparison of cultivation conditions revealed that EPS was produced when metabolic activity contributed to the culture media acidification to a pH of approximately 2. In conclusion, our study demonstrates R. toruloides' potential as an extracellular microbial biopolymer producer, enabling its consideration for extracellular bioproduction, besides its typically reported intracellular products.

Kewords: biopolymer, extracellular microbial biopolymer, extracellular polysaccharides, rhodotorula toruloides, oleaginous yeast

Aknowledgements: This work was supported by the Estonian Research Council (grant PRG1101) and from the European Union's Horizon Europe Teaming for Excellence program (grant 101060066), which is co-funded by the Estonian state budget.

CHARACTERISATION OF THERMOPLASTIC STARCH COMPOSITES WITH BIO-BASED ADDITIVES FOR FOAMING APPLICATIONS

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Biobased polymers are considered as an important prerequisite for more sustainable use of natural resources. Unfortunately, the volume of bio-based plastics, although gradually rising, still make less than 1 % from the total plastics market. This is largely related to higher production costs of bio-based polymers and often their lower exploitation properties in comparison to fossil-based polymers. Thus, there is a need synthesize new biopolymer modifications from abundant biomass sources (e.g., polysaccharides, proteins) and further develop application possibilities of the existing bio-based polymers. Consequently, the joint research is devoted to development of green thermoplastic foams with improved biodegradability and other exploitation properties.

The current report is focused on development thermoplastic starch-based composites with various waste biomass (e.g., agricultural residues and food industry residues) derived reinforcing fibers and other environmentally friendly functional additives to tailor rheological properties of the composites for foaming applications. The addition of these biobased additives is expected not only improve rheological behavior of the composites but also ensure better functional properties (e.g., insulation, mechanical, barrier) during and after the product life cycle (biodegradability).

To achieve the aim, in the first stage of the research the ultrasound assisted combined thermoplastic method is used for obtaining the composites. The effect of concentration, size, aspect ratio and surface treatment of different natural fillers (e.g., spelt husks, field-left agricultural residues) on the structural, rheological and mechanical properties of the obtained green composites is investigated.

Kewords: thermoplastic starch, composites, foams

Aknowledgements: This work was supported by the Project of Scientific Cooperation Program between Latvia, Lithuania, and Taiwan "Biopolymer based green thermoplastic foams with improved biodegradability for sustainable material technologies (GREENPLAST)" and received funding from the Research Council of Lithuania (LMTLT), agreement No S-LLT-25-4, the Latvian Council of Science, agreement No LV-LT-TW/2025/2, the National Science and Technology Council (NSTC), Republic of China (Taiwan), agreement No 114-2923-E-011-002-MY3.

SYNTHESIS AND PROPERTIES OF ONE COMPONENT CARDANOL-TYPE RENEWABLE MATERIAL USE IN SEALANT INDUSTRY

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One of the rising trends in modern research is the replacement of petroleum products with naturally renewable raw materials, but for the most part, the relevant systems are not available in sufficient quantities or their properties are worse than those of existing fossil-based materials.

Cardanol-type prepolymers are one of the most promising resources, because they are obtained in large quantities, and have high hydrophobic and ultraviolet light-protective properties, because of that they can even improve already existing sealant and adhesive properties.

In the relevant work, silyl-terminated prepolymers based on cardanol were synthesized, developing an alternative to polyurethane systems which would be less hazardous, potentially applying it to various industries that are looking for systems that are friendlier to the consumer.

The developed sealant systems showed mechanical (Figure below), adhesive properties and also climatic stability that were competitive with both silyl-terminated prepolymer systems and polyurethanes in the market.

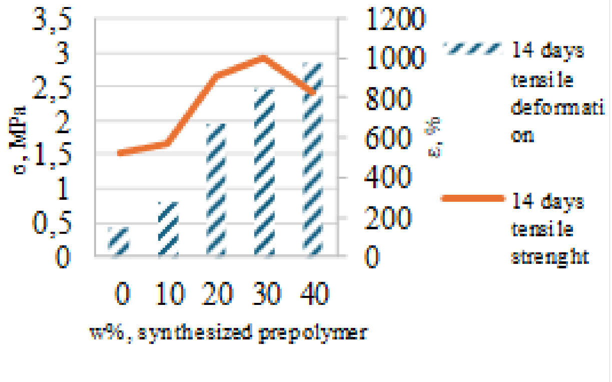

Figure. Tensile strength and ultimate deformation of the developed sealant systems.

Kewords: one-component system, cardanol, silyl-terminated pre-polymer

Aknowledgements: The work was implemented with the financial support of the W4747 Synthesis of silyl-terminated prepolymers from naturally occurring cardanol and their use in the creation of one-component adhesives with increased resistance to environmental factors, SANK, LV_UA /2023/8.

LIGNIN VALORIZATION VIA CHLOROMETHYLATION AS A VERSATILE APPROACH TOWARDS SUSTAINABLE MATERIALS

Mahendra Kothottil Mohan, Yevgen Karpichev

Tallinn University of Technology, Tallinn

Lignin is an abundant biopolymer with high carbon content and high aromaticity. Despite its potential as a raw material for fuel and platform chemicals, lignin remains the most underutilized of the lignocellulosic biopolymers. Lignin can be modified in various ways through "downstream" [1] and "upstream" [2] processing stages after it has been extracted. The chemically modified lignin can successfully lead to the manufacture of nanomaterials for drug delivery, depending on its source, chemical modifications, and physicochemical characteristics2. A variety of 'upstream' chemical modifications have been performed on lignin, including either the chemical modification of hydroxyl groups or the introduction of new chemically active sites. However, searching for a versatile and greener method remains challenging [3]. A greener chloromethylation process, which is experiencing a new wave of interest nowadays to yield a versatile product, opening up vast opportunities for further "greener" applications [4], has not been reported for lignin yet.

We developed a method for the chloromethylation of lignin, which enabled us to obtain a wide range of products using chloromethylated lignin (CLM) as the starting material. The resulting lignin-based materials include catalytic materials, antibacterial formulations, and thermoplastic additives. Our lignin-based catalyst offers several advantages over other catalysts, including ease of synthesis, heterogeneity, recoverability, and recyclability. We also confirmed the activity of the lignin-based catalyst in several carbon-carbon bond formation reactions, including the Suzuki-Miyaura, Sonogashira, Heck, and click reactions. A series of quaternary amines with variable chain lengths on chloromethylated lignin yields a range of novel surface-active materials with enhanced antibacterial activity against both Gram-negative and Gram-positive bacteria. Esterification with carboxylic acids of longer carbon chains altered the lignin-PLA composite's morphology and thermal properties. This research and lignin chloromethylation route will shed new light on lignin valorization and prove to be economically attractive and safe.

Kewords: chloromethylation, coupling reaction, lignin catalyst, quaternisation, antibacterial lignin, lignin-pla composites

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WE CAN MAKE ANYTHING FROM THE LIGNIN AND MONEY!

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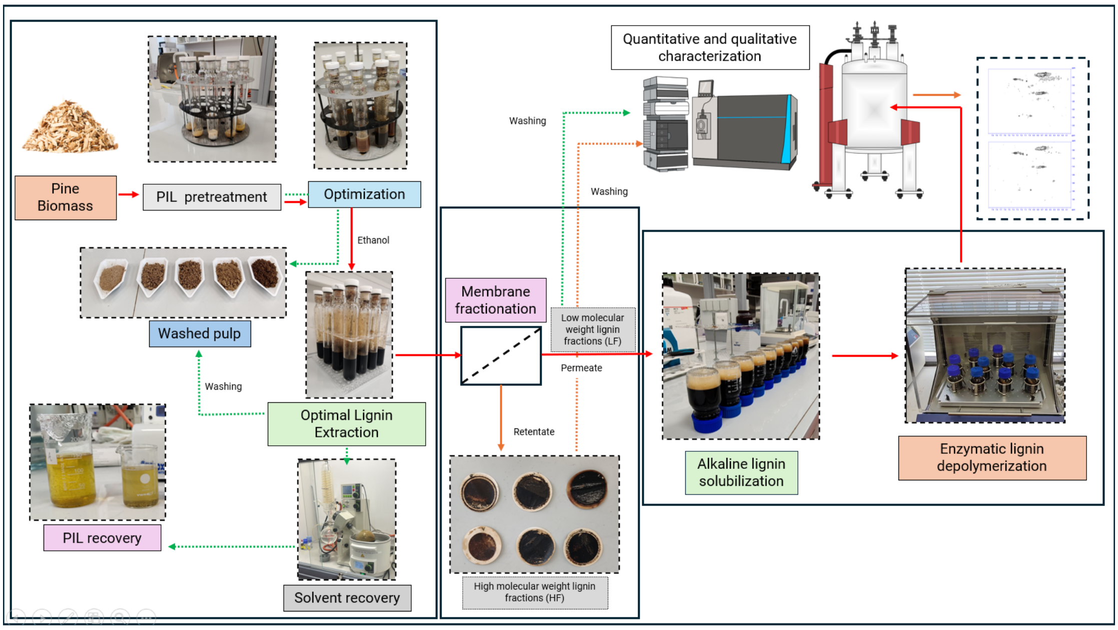
Presently, there are limited renewable alternative sources to replace fossils based materials and chemicals. One of the renewable option is lignin which is abundantly found in the lignocellulosic biomass (LCB) and currently a by-product in biorefineries and pulp industries. Biorefinery lignins and lignins coming from the pulp industry holds great potential for substituting materials and chemicals in biobased applications. In our study, we designed a protic ionic liquid (PIL)-based lignin fractionation method. where triethylammonium methane sulfonate [N222H] [OMs] PIL was used to facilitate LCB into cellulose, hemicellulose and lignin. Further the lignin was fractionated into lower molecular weight lignin fractions (LF) and the Higher molecular weight lignin fractions (HF). Later, the LF were depolymerized with the help of engineered laccases and both depolymerized lignin fractions and HF were characterized using advanced analytical techniques for high value compounds. Our vision is that the PIL based lignin fractionation method have the potential to be utilized at a large scale in order to substitute and developed the novel bio-based precursors that can be used as green chemicals and materials in fibre-based applications and drugs scaffolds.



Kewords: biorefinery lignin, protic ionic liquid, lignin fractionation, lignin depolymerization, high value compounds

Aknowledgements: Project "Cooperation between universities to promote doctoral studies" (2021-2027.4.04.24-0003) is co-funded by the European Union.

LIGNOCELLULOSE-BASED BIOCOMPOSITES AND 3D-PRINTED BIO-RESINS

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The transition towards sustainable materials has intensified interest in biocomposites reinforced with renewable biomass fibers. Among these, cellulose—owing to its biodegradability, renewability, and nanoscale versatility—has emerged as a leading candidate for developing advanced, eco-friendly materials. This presentation highlights multiple case studies exploring nanocellulose-reinforced vegetable oil acrylate resins, polybutylene succinate (PBS)/wood fiber composites, and materials derived from cellulose, hemicellulose, and lignin. Findings demonstrate that chemical modification of cellulose significantly enhances the thermal, tensile, and thermomechanical performance of PBS composites, with masterbatch processing emerging as a more sustainable alternative to solution or melt mixing. Furthermore, biodegradation rates of PBS/cellulose composites can be finely controlled by manipulating filler type, modification route, and content. This work also presents the development of high-viscosity, lignocellulose-reinforced bio-resins for extrusion-based 3D printing. Significantly outperformed single-filler counterparts, confirming the potential of lignocellulose-based bio-resins for producing customizable, sustainable 3D-printed materials.

Kewords: polymer composites, lignocellulose, 3d printing

EFFECT OF XYLAN EXTRACT ON PROPERTIES OF PHYSICALLY CROSSLINKED XYLAN/ POLY(VINYL ALCOHOL) COMPOSITE HYDROGELS

Svetlana Butylina, Youssef El Ouardi, Jesus Nuncira, Sami Virolainen

LAB University of Applied Sciences, Finland

Naturally available biopolymers can fill the demand for safe, low-cost, and sustainable materials. This study focused on the exploring of the properties of lignin-containing arabinoxylan compared with delignified xylan for the preparation of hydrogels. Two main features determining the application of hydrogels were studied: water sorption mechanism and dynamic shear rheological properties of swelled hydrogels. The AraXyl/PVA composite hydrogel had lower water sorption compared to Xyl/PVA hydrogel (5.82 ± 0.64 v's 10.27 ± 0.24 g/g); however, it was still higher than that of reference poly(vinyl alcohol), PVA, hydrogel (1.78 ± 0.13 g/g). A chemisorption was defined as a mechanism of water sorption by hydrogels. The decrease in viscoelasticity observed for the arabinoxylan/PVA and xylan/PVA composite hydrogels is directly associated with a decrease in the degree of crosslinking between the polymer chains in PVA. The addition of arabinoxylan resulted in stiffer hydrogel compared to one made with xylan; the storage modulus, G´ were 10.34 ± 0.14 and 7.16 ± 0.08 kPa for the AraXyl/PVA and Xyl/PVA, respectively. Xylans greatly impacted the structure and morphology of hydrogels, especially on the pore size and density.

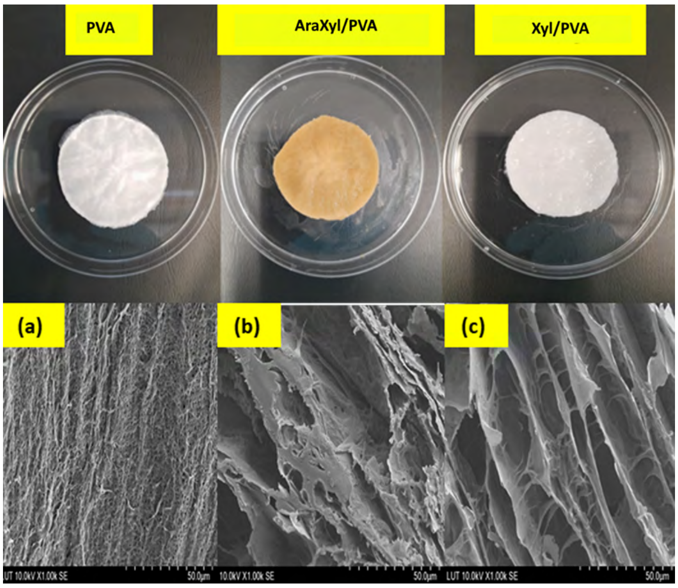

Figure: Photo of hydrogels samples and the SEM images of their cross-sections. a) reference PVA and composite, b) AraXyl/PVA, and c) Xyl/PVA hydrogels.

Kewords: lignin-containing arabinoxylan, water sorption, pseudo-kinetic models, gel fraction, viscoelasticity

Aknowledgements: Authors would like to thank the JTF funded BioFine development project for financial support.

EFFECT OF DRYING METHODS ON THE MORPHOLOGICAL AND FUNCTIONAL PROPERTIES OF CELLULOSE ESTER FILMS

Tanuj Kattamanchi, Heikko Kallakas, Elvira Tarasova, Percy Festus Alao, Tiit Kaljuvee, Arvo Mere, Atanas Katerski, Andres Krumme, Jaan Kers

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This study involved the preparation of cellulose long chain fatty ester films utilising various drying techniques, particularly the evaporation induced phase separation method (EPIS), which included hot air conventional oven drying (RO) and vacuum oven drying (VO). A new distillable ionic liquid, 5-methyl-1,5,7-triaza-bicyclo-[4.3.0] non-6-enium ac-etate [mTBNH][OAc], was utilised in the synthesis of cellulose esters, demonstrating a sig-nificant ability to dissolve cellulose when used in conjunction with DMSO as a co-solvent. The films were studied to evaluate the influence on the morphological and wettability properties of cellulose ester films using XRD, TGA, SEM, contact angle, and AFM techniques. The findings demonstrated that vacuum-dried films have a smooth sur-face and are hydrophobic in terms of surface wettability. Different drying conditions have little to no effect on the crystal structure of ester films, as indicated by the similar amorphous peaks in the XRD. The thermal stability of the films and their crystal structure were not affected by the varying drying conditions, as indicated by the TGA analysis. The SEM cross section images show a homogeneous, uniform film structure devoid of cavities and layers.

Kewords: solvent casting, vacuum drying, [mtbnh][oac], cellulose esters, polymer films, eips

Aknowledgements: The authors would like to acknowledge ERDF and the Estonian Research Council via project RESTA10 for supporting this research.

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VALORIZING LOW-QUALITY WOOD SPECIES INTO INNOVATIVE MULTILAYER ENGINEERED WOOD PRODUCTS

Tolgay Akkurt

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Valorizing Low-Quality Wood Species into Innovative Multilayer Engineered Wood Products

Plywood, composed of cross-laminated veneers bonded with adhesives under heat and pressure, is valued for its strength, dimensional stability, and wide range of applications. In Estonia, plywood relies almost exclusively on birch due to its excellent mechanical properties and uniform texture. However, increasing demand and limited availability of birch logs have raised costs and created the need for alternative hardwood species.

This study investigates the potential of aspen and black alder—traditionally considered low-value species—for plywood production, combined with thermo-mechanical veneer densification to enhance strength, surface hardness, and screw withdrawal capacity. The research integrates three objectives: (i) material substitution to reduce dependence on birch, (ii) evaluation of densification effects on mechanical and surface properties, and (iii) optimization of densification parameters for industrial application.

Results demonstrated that substituting birch with aspen and black alder is viable when veneer thickness and lay-up configurations are optimized. Densification significantly improved bending strength, surface hardness, and screw withdrawal capacity. However, reduced veneer thickness lowered the load-carrying capacity due to decreased moment of inertia, highlighting the importance of strategic veneer placement within the lay-up.

An optimization study of densification parameters showed that higher veneer equilibrium moisture content and increased hot-pressing pressure (5.4 MPa) promoted greater densification. Two pressing temperatures, 90 °C and 210 °C, produced optimal results: 90 °C was most suitable for industrial use due to lower energy demand and minimal degradation, while 210 °C achieved stronger densification but risked excessive thermal damage to wood structure.

Overall, this work provides a comprehensive pathway to valorize lower-cost hardwoods in engineered wood products, reduce reliance on birch, and refine veneer densification for industrial practice. The optimized process not only enables more sustainable and affordable plywood production but also broadens the application potential of densified veneers in construction and manufacturing industries. Furthermore, the identified parameters may be extended to birch and other hardwoods, supporting the development of higher-performance plywood in the future.

Kewords: veneer, lay-up, plywood, densification, density, screws, surface hardness, aspen, birch, black alder, bending strength

UNLOCKING THE POTENTIAL OF LIGNIN-CELLULOSE MIXTURE: A NEW PATHWAY TO SUSTAINABLE BIOMATERIALS

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Plant-based lignocellulosic biomass, i.e. wood and wood industry residues, is the main source of renewable chemicals. Unlike traditional cellulose-centred approaches, the aim of biorefining is to utilise 100% of the biomass. Most industrial-scale processes begin with pretreatment, converting hemicellulose into water-soluble sugars and producing a mixture of insoluble lignin and cellulose (LCM). LCM has no direct valuable use and always undergoes further processing to separate the components of cellulose and lignin as purely as possible. One option is to hydrolyse the cellulose enzymatically, yielding glucose and hydrolysis lignin. Alternatively, the lignin can be dissolved and microcrystalline cellulose obtained after bleaching. However, little attention has been given to the direct modification and application possibilities of LCM, where the two natural polymers complement each other. It has only recently been shown that cellulose and lignin interaction improves the properties of many materials, including wood adhesives, carbon and nanofibers, and food packaging. Developing direct applications for LCM would be useful for ensuring the sustainability of the biorefining concept by expanding the portfolio of valuable products.

We have investigated ways to valorise LCM directly into more valuable functional materials. We have used a high-power ultrasound method developed by our research group1,2 and also incorporated water-organic solvent extraction methods3. We have successfully developed lignin-nanocellulose-based materials, including hydrogels, aerogels and polyphenol cellulose composites.

Kewords: lignin-cellulose mixture, ultrasound, solvent fractionation, nanocellulose

Aknowledgements: This work was co-funded by the European Union and the Ministry of Education and Research via project TEM-TA85.

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FUNCTIONAL CHARACTERIZATION OF ACETYLATED-, SUCCINYLATED-, AND DUAL-MODIFIED POTATO PEEL STARCHES

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Potato peel, an abundant and accessible waste agro-waste, was valorised in this study as a sustainable source of starch for the development of various functional materials. Firstly, starch was extracted from the agro-residue and then chemically modified via succinylation (DDSA) and acetylation (Acetyl) to give different starch derivatives. Subsequently, the effect of the modifications on the morphological, thermal and pasting properties of the potato peel starch (PPS) was evaluated. A starch yield of ~19% was obtained from the potato peel and granules diameter of the starch granules varied between 3.73 and 41.86 µm. The starch derivatives obtained were potato peel starch derivatives with fixed degree of substitution of DDSA groups and varying degree of substitution of acetyl groups: DDSA-PPS (DSDDSA 0.021), Acetyl-PPS (DSAcetyl 0.29 & 0.67) and DDSA-Acetyl-PPS (DSDDSA 0.021, DSAcetyl 0.52 & 1.94). The morphology assessment of the granules of modified PPS showed structural changes in comparison to the native starch, while, FTIR showed the presence of additional groups, viz., C=O, RCOO, C–O and C-H in the derivatives. Furthermore, XRD of the starch derivatives showed a progressive shift towards amorphous character commiserate with the degree of substitution of the modified starches. While thermogravimetric analysis showed the typical 3-stage weight loss pattern in all the starches, the thermal stability of the double modified PPS was highest, followed by the acetylated PPS, with no significant difference between DDSA-PPS and PPS. The pasting properties of the derivatives changed significantly with DDSA-Acetyl-PPS (DSDDSA 0.021, DSAcetyl 1.94) exhibiting a complete loss of pasting properties. Overall, the results demonstrate the potential of PPS and its esterified derivatives to be used as main polymer matrix, co-matrix, and inert fillers in bioplastic development.

Kewords: agro-residues, bioplastic, potato peel, thermal stability, waste valorisation

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VALORIZATION OF USED COOKING OIL INTO AZA-MICHAEL DONORS FOR REPROCESSABLE THERMOSET POLYMERS

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The European Commission, through the European Green Deal and Circular Economy strategies, has outlined an ambitious roadmap toward sustainable development and climate neutrality by 2050. Despite this, the implementation of circular solutions in the field of polymer materials continues to pose major challenges. Central to these efforts is the reduction of reliance on fossil-derived feedstocks and the development of innovative strategies to minimize waste generation, enhance recyclability, and eliminate landfill use. Vitrimers—an emerging class of polymeric materials—offer a promising solution by combining the structural robustness of thermosets with the reprocessability of thermoplastics, enabled by dynamic covalent crosslinking. Their intrinsic recyclability and adaptability position them as strong candidates for advancing circular polymer systems and fostering a more sustainable materials industry.

The primary objective of this study is the development of bio-based β-amino polyester resins derived from used cooking oil. This work focuses on the synthesis of Aza-Michael donor molecules utilizing epoxidized used cooking oil as a renewable precursor. The oxirane functionalities present in the epoxidized triglycerides were reacted with various amines, including hexamethylenediamine, m-xylylenediamine, and tris(2-aminoethyl) amine, to yield bio-based multifunctional amines. These synthesized Aza-Michael donors were subsequently reacted with commercially available acrylates such as 1,6-hexanediol diacrylate and trimethylolpropane triacrylate, among others, to fabricate covalently adaptable thermoset networks.

The synthesized Aza-Michael donors were characterized using Fourier-transform infrared spectroscopy, amine value determination, viscosity measurements, and gel permeation chromatography/size exclusion chromatography. The resulting β-amino polyester resins were further analyzed by FTIR, while their thermal behavior was evaluated using differential scanning calorimetry, thermogravimetric analysis, and dynamic mechanical analysis. The tensile properties of the thermosets were also investigated. Recyclability was demonstrated via hot-press reprocessing, followed by evaluation of mechanical property retention. These bio-based resins represent a valuable pathway for upcycling waste feedstocks, supporting the advancement of sustainable and circular polymer materials.

Kewords: aza-michael donors, covalently adaptable networks

Aknowledgements: Research is funded by the Latvian Council of Science, project "Bio-based, Highly Crosslinked β-Amino Polymer Resins as Thermally Recyclable Building Blocks (TReResin)," project No. lzp-2024/1-0333.

FIRE-RETARDANT AND TRIBOLOGICAL PROPERTIES OF PAINTED ULTEM 9085 POLYMER SAMPLES PROCESSED BY FUSED DEPOSITION MODELLING

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The materials used for interior and non-structural components in the aviation industry must meet strict safety and performance criteria, particularly regarding flame retardancy and wear resistance. Ultem 9085, a high-performance polyetherimide thermoplastic, is widely used in aerospace applications due to its excellent strength-to-weight ratio and inherent flame, smoke, and toxicity compliance. However, the addition of surface coatings, such as paints, can alter the material's fire-retardant and tribological properties, potentially affecting its safety and functionality in service.

Investigating how painted Ultem 9085 samples behave under fire and frictional conditions is therefore critical to ensure that post-processing does not compromise compliance with aviation standards. Thus, the current work aimed to evaluate the effects of several paint coatings on the fire-retardant and tribological properties of Ultem 9085.

For the manufacturing of the raw samples, the Stratasys F900 machine was used. All samples were printed with 100% infill density, flatwise with a thickness of 1 mm, and the remaining dimensions were adjusted to meet the requirements for standard vertical burn (75 × 305 mm) and heat release (150 × 150 mm) tests. The vertical burn, smoke and toxicity, and heat release rate tests were carried out at Aeroworks Europe (Middenmeer, Netherlands) according to FAR/CS 25 Appendix F Parts I, IV and V of the aviation standard. At least three specimens were tested for each test group. Sliding friction tests were performed on painted Ultem 9085 samples using a ball-on-flat tribometer TRB 3 (CSM Instruments, Peseux, CH) under dry friction conditions according to ASTM G133-22. The sample surface 3D texture was measured with a 3D profilometer AVANT FTA-S4 S3000-D (Mitutoyo, Japan) before and after tribological tests to observe the wear impact on the surfaces.

Testing of seven paint coatings (PP1, PP4, PP5, PP7, PP8, PP9 and PP14) against the raw Ultem 9085 showed that while all paints reduced vertical burn length, indicating improved flame resistance, they also consistently increased both peak heat release rate (HRR) and smoke density compared to the raw Ultem 9085 samples. Overall scoring across the three key metrics (lower HRR, smoke density, and burn length) found the paint coatings PP4, PP1 and PP9 to offer the best performance amongst all, though neither outperformed the raw Ultem 9085 samples in all aspects. Tribology tests showed widely spread results of the coefficient of friction, varying from 0.2 (PP9) to 1.1 (PP5), and for the wear resistance, from near-zero wear (PP7, PP8) up to total destruction and failure of the painted layer (PP1, PP5), highlighting the extreme importance of choosing the correct paint for the desired task.

The results of the study allowed the selection of the most promising types of paints for demanding scenarios and indicated that while the paint coatings improved the flame resistance, they led to the generation of more heat and smoke during combustion.

Kewords: ultem 9085, 3d-printing, flame-retardant properties, tribological properties, post-processing, painting

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Poster presentations

1. DIBENZOTHIOPHENE OR SPIRO[1,3-DITHIOLANE-2,9'-FLUORENE]-BASED GLASS-FORMING HOLE-TRANSPORTING COMPOUNDS FOR PEROVSKITE SOLAR CELLS

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Organic hole-transporting materials (HTMs) are widely used in organic optoelectronic devices, particularly in perovskite solar cells (PSCs)1,2. Versatility of PSC is apparent in a variety of applications, from PSCs functioning optimally under one-sun illumination to indoor PSC capable of harnessing energy from artificial lighting3,4. With the aim to develop inexpensive, easily obtainable organic hole-transporting materials with low ionization potentials, high thermal and photochemical stability, high glass transition temperatures, high hole mobility for efficient and stable PSCs a series of new dibenzothiophene or spiro[1,3-dithiolane-2,9'- fluorene] derivatives were designed and synthesized via microwave-initiated Buchwald-Hartwig cross- coupling reactions. Thermal, electrochemical, photoelectrical and charge-transporting properties of the synthesized compounds were systematically studied. The synthesyzed HTMs demonstrate high thermal stability, with the temperatures of the onsets of weight loss of 309 - 408°C. All the compounds are capable of forming glasses with the glass transition temperatures of 99°C - 163°C. According to the results of photoelectron emission measurements, the studied compounds were characterised by ionization potentials ranging from 5.03 to 5.16 eV. In addition, TOF and CELIV measurements confirmed efficient hole transport in vacuum-deposited films with hole mobility reaching 4×10-4 cm2/V·s at the electric field of 9×105 V/cm. 2',7'-Bis[(4-methoxyphenyl)(9-ethylcarbazol-3-yl)amino]-spiro[1,3-dithiolane-2,9'- fluorene]-HTM based halide perovskite photovoltaic devices showed an optimized performance of 7.5% (FW), 13.5% (RV) and 14.55% (FW), 26.5% (RV) under 1-sun and 3000 K warm white LED (1000 lx) indoor illuminations, respectively.

Kewords: hole-transporting materials, perovskite solar cells, thermal stability, charge mobility

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2. EFFECT OF SUBERIN DEPOLYMERIZATION CONDITIONS ON THE FLAMMABILITY AND THERMAL STABILITY OF RIGID POLYURETHANE FOAMS

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Suberin, a natural polyester abundant in birch bark, is a promising renewable feedstock for the development of bio-based polymeric materials. In this study, birch bark suberin was depolymerized under three different conditions to obtain three suberinic acid fractions: SA1 (precipitated at pH 1), SA2 (precipitated at pH 5), and SA3 (precipitated using FeCl). These fractionation methods were chosen to potentially alter the chemical composition of the suberinic acids, including their presumed content of total phenolic compounds (TPC). Polyols were synthesized from each fraction following the approach described by Ivdre et al. , involving transesterification with trimethylolpropane and modification with tall oil fatty acids. The resulting suberinic acid-based polyols were used to produce rigid polyurethane (PUR) foams using an optimized formulation. The PUR foams were characterized using several standard methods, including measurements of apparent density and compressive strength, as well as flammability testing by cone calorimetry and thermal stability assessment via thermogravimetric analysis. To the best of our knowledge, the flammability behaviour of birch bark suberinic acid-based PUR foams has not been reported previously. Recent studies have highlighted the flame-retardant potential of several polyphenols like tannins and tannin-based plant bio-macromolecules, largely due to their aromatic structure and char- forming ability. However, our experimental results showed no significant differences in flammability among the rigid PUR foams derived from SA1, SA2, and SA3 fractions. Despite this, the viscosity of the polyols and the thermal stability of the resulting rigid PUR foams were influenced by the specific SA fraction used. This finding indicates that, under the tested conditions, the variation in TPC content was negligible and did not influence the flammability of the PUR foams. Therefore, other characteristics - such as polyol viscosity or thermal stability of PUR foams - may play a more critical role in determining PUR foam performance and should be prioritized when optimizing suberin depolymerization conditions.

Kewords: suberin, suberinic acids, phenolics, polyurethane foams, flammability

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3. DIRECT CONVERSION OF LIGNIN INTO ANTIBACTERIAL CARBON NANOMATERIALS WITHOUT ORGANOFUNCTIONALIZATION

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Nanotechnology has become a prominent scientific field, but many metal-containing nanoparticles—such as semiconductor quantum dots (2023 Nobel Prize in Chemistry)—contain toxic components. This has driven the search for safer alternatives, leading to the emergence of carbon dots (CDs) in 2004. CDs are a novel class of nanomaterials with highly carbonized cores and abundant surface groups, offering properties like fluorescence, biocompatibility, and aqueous stability, making them promising for biomedical applications. A major challenge is the sustainable and cost-effective synthesis of CDs. One promising strategy is to derive them from biomass, such as lignin—a polyphenolic polymer often discarded as industrial waste. Despite 100 million tons of lignin being produced annually, only 2% is recovered, presenting a unique opportunity for valorization. However, current biomass-based methods yield low quantum efficiency (below 10%) and generate impurities, limiting their practicality. This work aims to develop a sustainable method for synthesizing low-toxicity, highly luminescent CDs from lignin. We hypothesize that CDs with improved purity and antibacterial properties can be produced without post- synthesis organofunctionalization. Hydrothermal synthesis was performed using nitrogen-containing additives (primary, secondary, and tertiary amines) at 180–200 °C in water, followed by purification via dialysis. Optical properties were analyzed, and antibacterial screening was conducted against Staphylococcus aureus and Escherichia coli. CDs synthesized from lignin and ethylenediamine showed promising antibacterial activity against both bacterial strains. These findings highlight a viable pathway for producing sustainable nanomaterials with biomedical potential, advancing lignin valorization and green nanotechnology.

Kewords: lignin, carbon dots, antibacterial properties, hydrothermal synthesis

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4. EFFICIENCY BEHAVIOUR OF PLA/WOOD COMPOSITES EXTRUDED WITH AN INTENSIVE MIXING AND COMPRESSION SCREW ZONE

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Polylactic acid (PLA) is a biodegradable polyester with high application potential in the production of environmentally friendly materials. In recent years, there has been a growing interest in PLA composites reinforced with lignocellulosic fibers, such as wood flour or wood fibers, which increase the stiffness of the material while maintaining biodegradability. One of the main challenges is to ensure processing efficiency with high homogenization of the composite, appropriate thermomechanical and structural properties that will allow for the practical use of such materials, including in the construction, packaging or automotive industries. The addition of wood fibers improves the stiffness and increases the heat deflection temperature (HDT) of PLA composites [3]. At the same time, a decrease in tensile strength and impact strength is observed, which is related to the brittle nature of the PLA/wood material and problems with interfacial adhesion. The degree of weakening of these properties depends, among others, on the fiber content, their length, humidity and degree of fragmentation [4]. Mechanical and thermal properties are strongly dependent on the composite microstructure, including porosity, dispersion uniformity and fiber orientation. Thermomechanical studies, such as DMA, show that wood fibers act as a stiffening agent, reducing the strain amplitude in the glass transition temperature range of PLA [5]. The studies cover the extrusion process of a composite based on PLA Ingeo 4043D containing C320 soft wood flour (prod. ARBOCEL) in various proportions (0%, 15% and 30%). The process was carried out in a T-32-25 extruder equipped with a screw with a variable groove depth and a Maddock tip, enabling intensive mixing and shearing of the plasticized material. The studies included measurements of energy consumption, allowing determination of the energy efficiency of the process during increasing flour content and selected physical, mechanical and structural properties of the composite. The studies showed a slight decrease in the efficiency of the extrusion process and a significant decrease in the mechanical properties of the extrudate with the increase in the wood flour content. The structure analysis indicates the formation of small wood flour agglomerates in the extrudate and irregular porosities.

Kewords: extrusion, efficiency, composite, polylactic acid, wood

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5. TAILORING EPOXY MATERIAL PROPERTIES BY SOLVENT FRACTIONATION OF HYDROLYSIS LIGNIN

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Traditionally, epoxy resins are synthesized from bisphenol A, a petroleum-derived compound known for its adverse effects on human health and the environment. Lignin, as a sustainable alternative, presents significant potential due to its aromatic structure and abundance. However, the complex and heterogeneous nature of lignin, including its variable molecular weight, poses challenges for its direct use in material synthesis. To address this, solvent fractionation of wood hydrolysis lignin (HL) enables the isolation of lignin fractions with tailored properties suitable for direct epoxidation.1

In this study, we fractionated biorefinery wood HL with biobased water-organic solvents and these unique fractions were epoxidized under varying conditions. We systematically investigated the effect of synthesis conditions on the extent of epoxidation of phenolic and aliphatic hydroxyl groups. Various 100% biobased liquid epoxy resins were developed and these results and epoxy materials will be presented.

Figure: Valuable epoxy coating and adhesive derived from solvent-fractionated wood hydrolysis lignin.

Kewords: hydrolysis lignin, solvent fractionation, epoxides

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6. RHEOLOGICAL PROPERTIES OF FATTY ACID CELLULOSE ESTERS SYNTHESISED BY REACTIVE EXTRUSION

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Cellulose, being most abundant, relatively cheap and locally available biopolymer, is an attractive starting material for bioplastics production. However, rigid structure of cellulose limits thermoplasticity and melt processability in its natural state, [1]. This study investigates a continuous synthesis of fatty acid cellulose esters (FACE), namely cellulose laurates (CL), using reactive extrusion (REX) - a most promising method to produce thermoplastics without external plasticisers, [2]. CL were synthesised using a continuous one-step transesterification of microcrystalline cellulose (MCC) with vinyl laurate (VL) in an ionic liquid/co-solvent system ([EMIM][OAc]/DMSO). The process was carried out in a co-rotating twin-screw extruder under fixed speed and temperature conditions. REX was chosen for its advantages in scalability, shorter residence times, and ability to process higher cellulose concentration reaction mixtures, [3]. Rheological analysis was conducted on hot-pressed CL discs at 190 °C using oscillatory and steady shear tests. All samples exhibited non-Newtonian shear-thinning flow with viscoelastic properties characteristic of melt- processable thermoplastics. Increase in degree of substitution lowered the zero-shear viscosity, which indicated increase in internal plasticisation. Cole-Cole and Cox-Mertz plots suggested the presence of agglomerates and aggregates in the melt and variation in microstructure of materials. Despite this, samples demonstrated zero-shear viscosity in the range suitable for injection moulding and extrusion processing methods. The study confirms that REX is suitable method for continuous synthesis of thermoplastic cellulose esters with predictable rheological profiles. Analysis of flow behaviour supports their potential scale-up in sustainable material applications.

Kewords: reactive extrusion, cellulose laurate, rheology, biopolymer processing, thermoplastics

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7. FUNCTIONALIZATION OF SOFTWOOD SAWDUST GENERATED FROM PINE WOOD HONEYCOMB PRODUCTION FOR OBTAINING ENVIRONMENTALLY FRIENDLY COMPOSITE MATERIALS BASED ON RECYCLED POLYPROPYLENE

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The main disadvantage of softwood sawdust as a filler in wood-plastic composites (WPC) is the presence of resins in its chemical composition and its poor compatibility with synthetic polymers due to their different polarities. Due to these factors, the obtained composites have unsatisfactory exploitation properties. Targeted and scientifically based improved physicochemical functionalization of pine fibers by alkaline hydrolysis under the optimal conditions allows regulating the interaction between the pine fibers and the recycled polymer matrix and controlling the compatibility in the composite material. The replacement of organic solvents for removing the wood resins with the alkaline treatment responds to "Green" technology. In this study, suberinic acids was used as a biolubricant for improving the processing parameters of the WPC proceeded by extrusion with the following injection moulding. The composite samples filled with the functionalized pine fibers were characterized by increased mechanical properties and decreased wettability compared with the samples containing raw pine fibers. The incorporation of suberinic acids in the composite system led to a decrease in the minimal torque values of the co-rotating screws in the extruder in comparison with the torque indexes for the composite samples filled with the untreated pine residue.

Kewords: woodworking waste, alkaline functionalization, wood-plastic composite

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8. ANTIMICROBIAL BIOBASED VITRIMERS FOR LCD 3D PRINTING

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Vitrimers are a novel class of plastics that have cross-linked structure such as thermosets, but can be recycled same as thermoplastics . Vitrimers have attracted great attention due to their unique properties such as self-healing, self-welding, thermal reprocessability, chemical recycling and shape memory properties . In this study, a combination of two biobased monomers, produced by chemical modification of vegetable oils and bio-glycerol, a by-product of biodiesel production process, was used to synthesize a series of vitrimers and to investigate their properties. All vitrimers exhibited self-welding and reprocessability properties, as well as thermoresponsive shape memory properties with the ability to maintain not only one, but two temporary shapes. After reprocessability test the values of Young modulus of both, catalyst-free vitrimer and vitrimer containing catalyst, gradually increased after every cycle of reprocessability. The self-welding test showed that values of Young modulus of catalyst-free vitrimer remained the same after self-welding while the Young modulus values of vitrimer containing catalyst increased. All vitrimers showed high antimicrobial activity after 1 h of contact time against not only standard bacteria (E. coli and S. aureus) and fungi (A. flavus and A. niger) strains but also against other widely spread bacteria strains, including medically important ones (e.g. B. subtilis, P. aeruginosa), and fungal strains (e.g. C. cladosporioides, S. brevicaulis) often found indoors. The selected resin was applied in an LCD 3D printing production line at a company 3D Creative, and the 3D object was printed highly accurately with an even surface finish. The suitability for LCD 3D printing expands the developed material application areas to medical, aerospace, automotive, electronics, architecture, and other fields.

Kewords: antimicrobial, vitrimers, shape-memory, self-welding, lcd 3d printing, reprocessability

Aknowledgements: This research was funded by the Research Council of Lithuania (project No. S-MIP-23-52).

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9. DEPOLYMERIZATION OF POLYURETHANE FOAM WASTE WITH DIETHYLENE GLYCOL AND TALL OIL-BASED POLYOLS

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Polyurethane (PU) have been widely used for various application – as foams, insulation material, adhesives, coatings etc. Rigid PU foams are mostly used as insulation material in construction industry in refrigerators and freezers, meanwhile flexible PU foams can be found in furniture, cushions, etc. Besides PU, polyisocyanurate (PIR) foams can also be mentioned, which have higher thermal resistance and also can be used for insulation purposes . Naturally, this wide range of applications results in increasing waste products and, therefore, effective recycling methods must be investigated. So far, glycolysis is amongst one of the most commonly used depolymerization methods . Tall oil, by-product of cellulose production, is mainly mixture of two fatty acids – oleic and linoleic acid, besides resin acids and unsaponifiable compounds. Since these acids contain inert double bonds, epoxidation is commonly carried out, which results in highly functional material – epoxidized tall oil fatty acids (ETOFA), and further valuable polyols can be synthesized . In this research depolymerization of rigid PU and PIR foams was performed. At first, four different rigid PU and PIR foams were produced from bio-based and petro-chemical polyols with different isocyanate indexes (110 and 400) – 110bio, 110petro, 400bio and 400petro. Respectively, 110bio being foam from bio-based polyols with isocyanate index of 110 etc. Depolymerization process initially was performed using diethylene glycol (DEG) as glycolysis agent. Depolymerization process took place at the following conditions: temperatures 160, 170 and 180°C, ratio of foam:DEG as 1:1.5 and 1:2, catalysts potassium hydroxide KOH and zinc acetate Zn(Ac)2. Characteristics such as acid value, hydroxyl value, viscosity and water content was studied for obtained polyols, besides chemical structure which was analysed by FTIR and GPC/SEC. Obtained data showed that hydroxyl value of recycled polyols was around 500-700 mgKOH/g, naturally, polyols, which were depolymerized with higher DEG content, had higher hydroxyl value. Acid value of all polyols was <6 mgKOH/g. From FTIR spectra it was observed that typical urethane bonds have decreased, even though reduction was rather insignificant. From these results it can be concluded that promising polyols can be obtained in lower temperatures and with lower foam:DEG ratio. Also, PU and PIR foam depolymerization with TOFA based polyols was also performed, in hope of partially or completely replacing DEG. This was done in order to obtain polyols with higher renewable material content and lower hydroxyl value. Developed polyols will be used for synthesis of Michael donor components, from which polymer resins through acrylation process can be obtained.

Kewords: polyurethane, polyisocyanurate, recycling, depolymerization, tall oil polyols

10. PYRIDO-PYRAZINE DERIVATIVES AS NOVEL EMITTERS EXHIBITING EFFICIENT TADF FOR OLEDS

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Thermally Activated Delayed Fluorescence (TADF) materials have become very important as alternatives to traditional metal-based emitters in organic light-emitting diodes (OLEDs). Recent studies show purely organic TADF materials are low-cost, eco-friendly emitters for advanced displays and lighting [1]. However, creating TADF emitters with high efficiency and specific colors, especially for high-performance OLEDs, is still an area of active research. In this investigation, the light-emitting properties and possible uses of new Pyrido[2,3-b]pyrazine derivatives connected to either carbazole or phenothiazine groups were studied. This included their ability to absorb and emit light, how efficiently they emitted light (quantum yields), the lifetimes of their excited states, and the energy difference between their singlet and triplet states (ΔEST). These materials exhibited TADF with small ΔEST values (as low as 0.16 eV), spanning green–orange emission and quantum yields up to 82%. Furthermore, the application of these new Pyrido[2,3-b]pyrazine-based TADF emitters in OLED devices was explored. Through optimization of using a host-guest system, an external quantum efficiency (EQE) of 21.3 % was reached, accompanied by a high current efficiency of 52.5 cd/A and a brightness of 7202 cd/m². The achieved device efficiencies are approaching the theoretical limits for TADF OLEDs [2]. These new materials are promising for use in a wide range of light-emitting applications, including energy-efficient displays and lighting.

Kewords: pyrido-pyrazine, tadf, oled

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11. DEVELOPMENT OF BIO-BASED LIGNIN-FURFURAL ADHESIVES USING DEEP EUTECTIC SOLVENTS

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The search for sustainable alternatives to fossil-derived wood adhesives has intensified in recent years due to environmental and health concerns associated with conventional resins, such as phenol-formaldehyde (PF) resin [1]. Kraft lignin, an abundant and underutilized byproduct of the pulp and paper industry, offers potential as a renewable feedstock for adhesive production when combined with bio-based crosslinkers, such as furfural [2]. However, due to its heterogeneous structure, poor solubility, and limited reactivity, lignin is difficult to directly react with furfural to form an effective adhesive. To address this, deep eutectic solvents (DESs) were employed to both improve lignin solubility and enhance its chemical reactivity toward furfural. In this study, lignin-DES-furfural (LDF) adhesives were prepared using choline chloride as the hydrogen bond acceptor (HBA) combined with five different hydrogen bond donors (HBDs) to assess their influence on adhesive performance. A selection of organic acids and urea were evaluated for their effects on lignin solubility, polymerization behavior, and mechanical bonding strength. Adhesive performance was tested using a single-lap shear strength method, while molecular changes during reaction were monitored via Fourier-transform infrared spectroscopy (FT-IR) and size exclusion chromatography (SEC). Th results revealed that the choice of HBD significantly impacted both processing behavior and adhesive properties, with certain formulations offering improved solubility and bonding performance. These findings provide valuable insights into the role of DES composition in bio-based adhesive design and lay the groundwork for further optimization toward industrial applications.

Kewords: bio-based adhesive, lignin adhesive, kraft lignin, deep eutectic solvents

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12. CELLULOSE IN CHOLINE CHLORIDE-BASED DEEP EUTECTIC SOLVENTS: DISSOLUTION, REGENERATION, AND ACETYLATION

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The increasing demand for sustainable and environmentally friendly alternatives to conventional solvents has sparked interest in deep eutectic solvents (DESs) as promising media for dissolving and processing biopolymers, such as cellulose. Cellulose, the most abundant natural polymer, has unique mechanical and chemical properties due to its extensive hydrogen bonding network and semicrystalline structure. However, its poor solubility in traditional solvents, caused by strong inter- and intramolecular hydrogen bonds, poses a significant barrier to its broader application in materials science, biotechnology, and green chemistry. DESs, created by combining a hydrogen bond donor (HBD) and hydrogen bond acceptor (HBA), provide a low-cost, biodegradable alternative to traditional solvents. Notably, those based on choline chloride (ChCl) with urea (Ur) or oxalic acid (OxAc), have shown potential for cellulose dissolution. This research investigates the solution behaviour of cellulose in two DES systems: ChCl/Ur (in a MR of 1:2) and ChCl/OxAc (also in a MR of 1:2). The focus is on their solvation capabilities, solution rheological properties, microstructural characteristics, and impact on the molar mass and structure of cellulose after regeneration. This study uses visual inspections, rheological measurements, microscopy, NMR, and XRD to assess the effectiveness of each DES in dissolving cellulose and to clarify the mechanisms of cellulose–solvent interactions in these green solvent systems. The findings revealed key differences between the two systems. The ChCl/Ur system exhibits better homogeneity and dissolution capacity for cellulose, but neither system completely dissolves it. Instead, cellulose may aggregate or undergo partial dissolution, mostly leading to swelling. Structural analyses showed that the regenerated cellulose retains its native cellulose I crystalline structure, with only slight transformation to cellulose II. A higher crystallinity index (CI) in the regenerated cellulose indicates that the DESs are ineffective at dissolving the crystalline portion, although they can dissolve the amorphous part. It was also shown that the acetylation of cellulose in the DESs was inefficient due to poor cellulose solubility, immiscibility of the components, and competition for hydrogen bonding with the acetylating reagents. This work enhances research on DES formulations for cellulose processing. As DESs are promoted as eco-friendly compared to traditional solvents, it sets realistic expectations and guides future developments towards more effective DES systems for biomass processing.

Kewords: choline chloride, deep eutectic solvents, cellulose dissolution, cellulose regeneration, cellulose acetylation

Acknowledgements: This research is funded by Research and Development Project "New biomaterials made by reactive extrusion from cellulose and by-products of vegetable oil production TEM-TA103".

13. PHENOLATION-ASSISTED DEPOLYMERIZATION OF HYDROLYSIS LIGNIN FOR FUNCTIONAL MATERIAL DEVELOPMENT

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The growing demand for epoxy materials has prompted the search for alternatives to bisphenol A (BPA)- based resins, which pose environmental and health risks during its manufacturing process. Hydrolysis lignin (HL), a product of wood biorefining, offers a promising renewable feedstock of phenols due to its aromatic structure and abundance in hydroxyl groups. However, unmodified HL typically yields solid epoxy resins, limiting its practical applications. This study explores methods for synthesizing non-solid epoxy resins from HL in three steps. 1) HL is dissolved in recyclable solvents, such as a mixture of a bio-based organic solvent and water. This selects the best lignin fraction for further processing. 2) Phenolation is performed using phenol or catechol, which are potentially lignin-based products. In this step lignin depolymerises partially. 3) The phenolated lignin is then glycidylated with epichlorohydrin to produce a non-solid, viscous liquid or putty-like epoxidised lignin.

Kewords: hydrolysis lignin, phenolation, epoxidation

Acknowledgements: This work was co-funded by the European Union and the Ministry of Education and Research via project TEM-TA85.

14. DEVELOPMENT OF BIO-BASED EPOXY COMPOSITE FOR FBG SENSOR EMBEDDING IN ASPHALT CONCRETE FOR STRUCTURAL HEALTH MONITORING

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Structural Health Monitoring (SHM) of civil infrastructures becomes more and more important for sustainable development of the Earth. SHM may prevent technological catastrophes, as well as decrease recovery expenses. Besides it SHM may act as a tool for monitoring of changes in anthropogenic or natural systems over the long-time scale. For reliable SHM the sensors (e.g., FBG) must be tightly embedded within the civil structure, ensuring long-term function. It is also important that the binder may be obtained from bio-based sources and/or non-toxic industrial or municipal waste, yet ensuring sufficient resistance in the application environment. Consequently, the current research is devoted to development of composite binder composition for FBG sensor embedding in asphalt concrete. For development of the binder composition, different precursors (with epoxy, acrylate, cardanol functionalities) and reinforcing agents (CaCO3, waste glass powder) have been were combined to obtain composites suitable for sensor embedding in asphalt concrete. Performance efficiency of the developed binder compositions by itself have been assessed by flexural, glass fiber pull-out and chemical resistance tests; as well as 4-point fatigue tests of asphalt concrete bars with embedded sensors were carried out. The first experimental results testify that by tailoring the composition of the system it is possible to obtain binder, suitable for embedding FBG sensors in asphalt concrete for SHM. Future tasks are related to optimizing the composition of the resin for easier and less-time consuming embedding process, to increasing the content of bio-based and/or recycled materials in the composition, as well as to ensuring recyclability of the final material (asphalt concrete with embedded sensor).

Kewords: epoxy composite, fiber bragg grating sensor, asphalt concrete

Acknowledgements: Development of fiber Bragg grating sensor network for road pavement monitoring (Nr. RTU-IG-2024/1- 0014).

15. BIOFINE - LEAP OVER DEAD WALLEY

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LAB Biofine is a project that creates a pilot plant and a collaboration ecosystem around bioprocessing. The project helps companies pilot their innovations and projects and conduct proof-of-concept experiments. The pilot plant is a high TRL (5-8) platform for future projects and innovations. The ecosystem around it serves as a collaboration platform with companies, research institutes and universities. The ecosystem covers research, development and innovation, education, business collaboration and shared infrastructure that can be used to achieve an efficient value chain.

Kewords: pressurized hot water extraction, green solvents, ecosystem, pilot services

16. VALORIZATION OF MECHANICALLY RECYCLED TEXTILE FIBRES INTO NONWOVEN MATERIALS WITH VARIOUS COMPOSITIONS

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The growing production and consumption of textiles has resulted in increasing volumes of waste, much of which in Europe is still landfilled or incinerated. This highlights the urgent need for circular economy strategies and efficient valorization routes for post-consumer textiles. Mechanical recycling can convert textiles back into a fibrous state; however, the reduced fibre quality often limits their reuse in yarn production. Converting recycled fibres into nonwoven materials offers a promising alternative, yet the effects of fibre composition and processing parameters on material performance remain insufficiently studied.

This study explores the impact of carding methods and pressing temperatures on the physico-mechanical properties of thermally bonded nonwovens made from mechanically recycled cellulosic, synthetic, and protein fibres, with polylactic acid (PLA) used as a binder fibre. Nonwovens prepared using both a drum carder and an electric drum carder, followed by pressing at 120–140 °C, were evaluated for mass per unit area, bending rigidity, specific stress, and elongation at maximum load. Nonwovens produced with drum carder exhibited higher mass per unit area, rigidity, and strength, while electric drum carder enabled faster and more uniform processing. Higher pressing temperatures generally improved strength and rigidity across all compositions. Synthetic-based nonwoven materials achieved the highest strength, wool-based nonwovens showed the highest bending rigidity, and cellulose-based nonwovens had highest mass per unit area, but comparatively lower strength.

The findings demonstrate the potential of mechanically recycled fibres to be valorized into functional nonwoven materials, contributing to sustainable material development and textile waste reduction.

Kewords: nonwoven materials, mechanical recycling, textile waste, circularity

Acknowledgements: This work was partly funded by the Ministry of Education and Research through Centre of Excellence in Circular Economy for Strategic Mineral and Carbon Resources (01.01.2024–31.12.2030, TK228).

17. SEPARATION AND CHARACTERIZATION OF SOLUBLE AND INSOLUBLE PHASES FROM CELLULOSE LAURATE (CL) FOR BIOPLASTIC COATING APPLICATIONS

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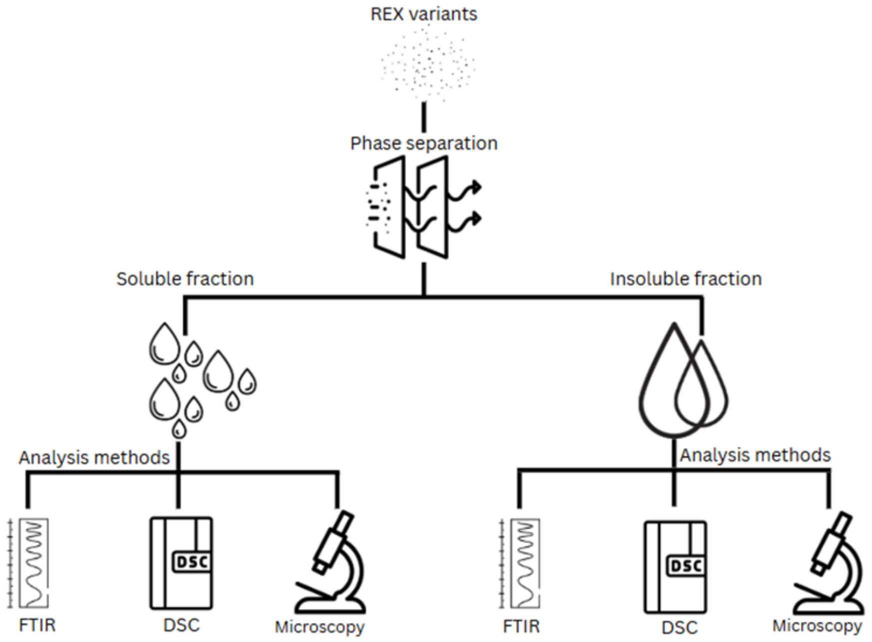
In pursuit of sustainable alternatives for paper coatings, this research examines several cellulose laurate (REX) variants, separating their soluble and insoluble phases and analysing them via FTIR, DSC, and microscopy to identify properties relevant for industrial bioplastic applications.



Kewords: cellulose laureate, bioplastic coating, phase separation, ftir, dsc, microscopy.

Acknowledgements: Estonian Research Council. Project TEM-TA 103.

18. MECHANICAL PROPERTIES OF FIRE DAMAGED AND BARK BEETLE (IPS TYPOGRAPHUS) ATTACKED NORWAY SPRUCE (PICEA ABIES) WOOD

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An increasing problem of Spruce bark beetle (Ips typographus) attacks on softwood, particularly Norway spruce (Picea abies) has lead to a situation where there is a large stock of blue stained material [1]. This kind of material is often undesired by the customers as unreliable and anaesthetic material. Nevertheless, beetle attacked wood, when harvested and processed in a comparatively short time (not more than 3 years after attack), has mechanical properties still comparable to a standard material [1,2,3]. Our study shows initial results on mechanical and physical properties of blue stained Norway spruce wood samples.

Kewords: bark beetle, blue stain, wood properties, norway spruce

Acknowledgements: The research has been co-funded by the EU structural funds and the Ministry of Education and Research Under the project TEM-TA80.

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19. FROM WOOD BIOMASS TO BIO-BASED LEATHER: HIGH-VALUE APPLICATIONS OF HYDROLYSIS LIGNIN

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Polyurethane (PU) is widely used in artificial leather because it combines soft touch, realistic grain, flexibility and breathability. Typical PU leather structure consists of three layers: base fabric, PU foam layer (adds bulk and softness), PU topcoat layer (dense, colored, embossed). This sandwich structure gives the look, feel and mechanical properties of natural leather. Finding bio-based alternatives with properties corresponding to fossil PU is a huge challenge. The possible use of polyester or −ether diols based on wood sugars (soft segments) and lignin (hard segments) as a backbone to create bio-based PU layers of synthetic leather has been the maddening task of this work. Adding lignin to PU significantly increases the durability of the materials. In this work, we investigated the suitability of different solvent fractions of hydrolysis lignin (HL) to produce leather layers with various properties. We successfully prepared the materials for the PU foam and topcoat layers, which feature a natural leather pattern, from fractionated HL and diols.

Kewords: hydrolysis lignin, polyurethane, diols, solvent fractionation, artificial leather

Acknowledgements: This study was co-funded by the European Union and the Ministry of Education and Research via project TEM-TA85..

20. PHENOXATHIIN DERIVATIVES SHOWING ROOM-TEMPERATURE PHOSPHORESCENT FOR EMISSIVE TAG APPLICATIONS

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The recent studies have highlighted the potential of organic room-temperature phosphorescence (RTP) materials for applications such as bioimaging, organic light-emitting diodes (OLEDs), dynamic light therapy, data encryption, and anti-counterfeiting [1]. The long emission lifetime of RTP materials makes them unsuitable for OLEDs [2]. However, this characteristic allows their use in electronics-free thin-film information storage systems and wavelength-tracking sensors [3]. Emissive tags, which rely on long-lived luminescence, can serve in anticounterfeiting, labeling, and data exchange [3]. Phenoxathiin is still scarcely used as an electron donor moiety. It was selected due to its distinctive structure, which includes oxygen and sulfur atoms [4]. This moiety is expected to enhance spin–orbit coupling, promoting intersystem crossing from the singlet to the triplet state, which is essential process for phosphorescence. In this study, we report the synthesis, thermal, and photophysical properties, as well as the theoretical study of three new electron-accepting quinoxaline derivatives and three phenoxathiine containing donor–acceptor type compounds, as potential candidates for emissive tag fabrication.

Kewords: phenoxathiin, room temperature phosphorescence, emissive tags

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21. THE EFFECT OF PRESSING PARAMETERS ON THE PROPERTIES OF NONWOVEN COMPOSITES

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Growing amounts of textile waste are a major problem impacting the environment and human life. In previous research several types of nonwoven composites from mechanically recycled textiles fibres have been developed. However results have showed that the properties of nonwoven composites are significantly different although materials and processes used are similar. In previous studies the effect of the variation of pressing parameters has not been adequately discussed. The main aim of the current research was to analyse the effect of pressing parameters on the physico-mechanical properties of nonwoven composites made from mechanically recycled textile fibres. Composites were prepared from mechanically recycled synthetic textile fibres and low-melting polyester fibres in a 50:50 ratio. The preparation process of composites involved carding, fusing, and hot-pressing, where different pressures and consolidation durations were applied. The effect of various pressing parameters on the properties of nonwoven composites was analysed by performing tensile, flexural, and impact strength testing. The maximum tensile and flexural strength values received were (56.34 ± 2.03) MPa and (53.95 ± 3.46) MPa, respectively, which were obtained for the composite developed at 7 MPa pressure and 10 minutes consolidation time. The highest impact strength was (64.09 ± 3.60) kJ/m2 obtained for the composite developed under 9 MPa pressure and 10 minutes consolidation time.

Kewords: circular economy, textile waste, recycled fibre, nonwoven, composite

Acknowledgements: This work was partly funded by the Ministry of Education and Research through Centre of Excellence in Circular Economy for Strategic Mineral and Carbon Resources (01.01.2024–31.12.2030, TK228).

22. SYNTHESIS AND INVESTIGATION OF GLASS FORMING DERIVATIVES OF QUINOXALINE AND PHENANTHROIMIDAZOLE AS LUMINOPHORES FOR EFFICIENT OLED

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Over the past few decades, organic light-emitting diodes (OLEDs) attracted the interests of researchers and developed considerably, providing many advantages such as high contrast ratios, wide viewing angles, flexibility, and energy efficiency [1]. Hybridized local and charge-transfer (HLCT) emitters present a viable approach for the development of high-performance, economical, and eco-friendly OLEDs [2]. Because of high photoluminescence quantum yields (PLQY), and strong thermal stability, dęrivatives of phenanthroimidazole combining the phenanthrene and imidazole moieties, are good candidates for the developments HLCT-based fluorophores [3]. Recent studies investigated quinoxaline-based compounds for application in OLEDs, revealing that OLEDs utilizing these materials exhibit considerable potential, achieving elevated photoluminescence quantum yields and improved external quantum efficiencies [4,5] This research in on the the synthesis and examination of several derivatives of quinoxaline and phenanthroimidazoles as prospective materials for OLEDs. The assessment of these materials indicated that the synthesized compounds exhibited ionization potential of 5.64 and 5.98 eV. They also showed glass forming properties. When molecularly dispersed in the rigid inert polymer Zeonex, the compounds exhibited high-intensity emission with PLQY of 45 and 56, positioning them as potential candidates for OLEDs.

Kewords: quinoxaline, phenanthroimidazole, hlct, oled

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23. ULTRASOUND-DRIVEN INNOVATION IN LIGNIN-NANOCELLULOSE MATERIALS

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Typically, lignocellulosic wood biomass in a biorefinery is pretreated by first separating hemicellulose C5 sugars and an intermediate product, lignin-cellulose mixture (LCM). The LCM is then converted into either C6 sugars and hydrolysis lignin, or microcrystalline cellulose and dissolved lignin. LCM has not yet found direct application in the production of high-value materials. However, studies have shown that, in certain applications, lignin and cellulose can work together to improve the properties of some novel materials. Studies have demonstrated that lignin significantly affects the morphology and colloidal stability of cellulose nanofibers, thereby influencing the properties of materials such as hydrogels, filaments, and composites. Nanocellulose is typically produced from highly purified cellulose through acid treatment. However, this cannot be performed with LCM due to lignin condensation. We present a high-energy ultrasound-assisted method developed by our research group for directly preparing lignin-nanocellulose from LCM.1 We prepared formaldehyde-free phenolic resins from lignin-nanocellulose and tested their properties as adhesives. While nanocellulose enhances mechanical strength and stability of the adhesives, lignin is the reactant for crosslinking reactions furthering mechanical strength of the adhesives and cross- linked lignin is an adhesive matrix.

Kewords: lignin-cellulose mixture, ultrasound, nanomaterials

Acknowledgements: This work was co-funded by the European Union and the Ministry of Education and Research via project TEM-TA85.

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24. POLYMER COMPOSITES BASED ON POLYTETRAFLUOROETHYLENE (PTFE) AND SILVER FOR FRICTION PARTS IN FOOD INDUSTRY EQUIPMENT

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When developing equipment for the food industry, significant attention should be paid not only to design, technological, and economic aspects, but also to preventing bacterial contamination of its main components, especially those that come into contact with food products. One of these components is friction pairs. In food equipment, they are made of inert materials, including some stainless steels, ceramics, polymers, etc. [1]. Moreover, the most promising materials for such units are polymers. They have a number of significant advantages over other materials: a high level of resistance to the action of various environments, a sufficiently high level of physical, mechanical and thermophysical properties, the ability to operate in friction units without or with boundary lubrication [2,3]. The effect of finely dispersed silver on the physicomechanical, thermophysical and tribological properties of a polymer composite based on PTFE has been established. It has been determined that the introduction of silver into polytetrafluoroethylene improves the Brinell hardness from 39.0 to 51.0 MPa, the yield stress in compression from 12.0 to 17.5 MPa and the modulus of elasticity in compression to 645 MPa. An increase in the Vicat softening temperature and the temperature of onset of active destruction for the developed composites was determined to 168 and 452°C, respectively, compared to the original PTFE. It was found that the developed composites have 10-15% better friction coefficient values and 1.6-1.7 times higher wear resistance than the original PTFE, which, together with the results of studies of the physical, mechanical and thermophysical properties of the developed composites, allows them to be recommended for use in friction units and sealing of food industry equipment.

Kewords: polymer, ptfe, silver, physicomechanical and tribological properties

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25. GREEN NON-DESTRUCTIVE APPROACH FOR QUANTITATION OF HYDROXYL GROUPS IN LIGNIN USING ATR-FTIR SPECTROSCOPY AND CHEMOMETRIC METHODS

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Rapid growth in the demand for sustainable materials has increased the need for biorefineries, where the accuracy of lignin characterization is essential for understanding lignin reactivity and valorization potential. This study investigates the use of attenuated total reflectance Fourier-transform infrared (ATR-FTIR) spectroscopy combined with chemometric modelling as a sustainable alternative for the classical phosphorus nuclear magnetic resonance (31P-NMR) spectroscopy in quantitative analysis of lignin hydroxyl group quantitation. Organosolv lignin samples were analyzed by (31P-NMR) to calculate the content of hydroxyl groups, and a separate ATR-FTIR measurement was conducted. This data was used with multivariate analysis methods such as PLS, iPLS, SVM, and iPLS-SVM to create predictive models with high performance characteristics. With the exception of guaiacyl, the models showed high predictive performance for all hydroxyl types (R2Pred > 0.95), and the residual predictive deviation (RPD) values exceeded 4 for the aliphatic, syringyl, and p-hydroxyphenyl groups. Compared to the classical (31P-NMR) method, the proposed new method reduced analysis time and eliminated hazardous solvents, and improved AGREE greenness score (0.39 vs 0.88). These results demonstrate the capabilities of ATR-FTIR spectroscopy combined with chemometrics to offer a robust, rapid, and eco-friendly alternative for lignin analysis suitable for implementation in a biorefinery.

Kewords: lignin, ftir, nmr, multivariate analysis

26. PARAFORMALDEHYDE DEPOSITS AS A RECOVERABLE FORMALIN SOURCE: FEASIBILITY STUDY FOR SUSTAINABLE UF RESIN PRODUCTION

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In urea-formaldehyde (UF) resin manufacturing, high-concentration formalin solutions without methanol are commonly used due to economic and synthetic efficiency. However, this practice often leads to gradual paraformaldehyde (PFA) accumulation in formalin storage tanks, especially under conditions of suboptimal insulation, prolonged storage, or ambient cooling. These solid deposits present both technical and environmental challenges, typically being treated as chemical waste and incinerated. This study explores an alternative approach: recovering PFA from such deposits via controlled depolymerization into formalin, and reintroducing the regenerated solution into resin synthesis. The proposed methodology involves heating the PFA–water suspension to 60–90 °C in the presence of dilute alkaline catalyst (e.g., sodium hydroxide), facilitating base-catalyzed hydrolytic depolymerization. The resulting formalin solution is filtered and characterized to ensure compatibility with standard UF resin synthesis parameters. Preliminary resin batches produced with the regenerated formalin demonstrate acceptable reactivity and physical properties, indicating that reintroduced material may substitute part of the primary formaldehyde feedstock without compromising performance. The process is designed for on-site implementation using existing mixing and reaction infrastructure, minimizing material losses and eliminating the need for external disposal.

Kewords: paraformaldehyde depolymerization, formalin recovery, uf resin synthesis, aqueous alkaline hydrolysis, sustainable adhesive production

27. STRUCTURAL AND MECHANICAL PROPERTIES OF THERMOPLASTIC STARCH COMPOSITES WITH AQUATIC BIOMASS ADDITIVES

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Responsible long-term management of available natural resources unavoidably considers minimizing the use of the non-renewable Earth's wealth and its replacement with bio-based raw materials at reasonable costs. Fortunately, the Earth is rich of renewable biomass sources from which starch, carrageenan, cellulose and other natural compounds may be extracted. These natural compounds are a basis for great part of presently known biopolymers, including thermoplastic starch, PLA, PBS and others. In the light of these findings the current research focuses on the development of fully bio-based binder composites from thermoplastic starch, carrageenan, extracted from the Baltic red algae (Furcellaria lumbricalis), reed or club rush lignocellulose and other natural functional additives like nanoclay and chitosan. These composites have been obtained by using ultrasound assisted combined thermoplastic compounding approach. The effect of reed, club rush, nanoclay and chitosan concentrations on the structural, mechanical and adhesive properties of carrageenan modified thermoplastic starch matrix have been investigated. Positive modifying effect of the nanoclay and lignocellulosic biomass reinforcements on the mechanical properties of the thermoplastic starch/carrageenan composites has been ensured by optimizing the fillers size, concentration and dispersion degree within the polymer matrix as well as by tailoring the interphase morphology.

Kewords: thermoplastic starch, alginate, coastal biomass, composite, structure, mechanical properties

Acknowledgements: Valorisation of local aquatic biomass to develop environmentally friendly composite material (AQUABOND) (Nr. RTU-PA-2024/1-0048).

28. ENGINEERING AND PRODUCTION OF MFP5-CSGA FUSION PROTEIN ADHESIVES IN *KOMAGATAELLA PASTORIS*

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Bio-inspired adhesives are in high demand for applications ranging from industrial bonding and underwater coating, to wound closure and bone tissue repair. Mussel foot proteins (Mfps), which enable mussels to adhere strongly to wet surfaces, represent promising natural templates for such technologies. However, direct extraction from mussels is unsustainable and yields limited quantities, underscoring the need for scalable recombinant production systems.

Through recombinant protein engineering, adhesives with enhanced material-forming and adhesive properties can be generated, including amyloid fiber-forming protein fusions of Mfp-5 with bacterial curli protein CsgA. This work aims to utilize rational protein engineering to improve functional properties of such adhesive proteins.

In this study, we engineered *Komagataella pastoris* from OPENPichia® platform, a well-established host for recombinant protein production, to express a heterologous Mfp5–CsgA adhesive protein. The coding sequence was codon-optimized for yeast expression, cloned into a vector, and integrated into the K. pastoris genome under the AOX1 promoter. Protein production was studied using lab-scale bioreactors. Growth and induction conditions—including methanol feed rate to induce target protein expression, and temperature—were optimized to maximize protein yield in high-cell-density fermentations. Cells were collected, lysed, and used for Western blot analysis, which showed a clear band at the expected molecular weight, confirming successful expression of the fusion protein. However, further optimization of growth and induction conditions is required to improve recombinant protein yield.

These results represent the initial stage of a broader project focused on developing bio-inspired protein-based adhesives. Additional proteins will be incorporated into similar fusion designs to expand the repertoire of sustainable, bio-based adhesives produced in K. pastoris. Building on this platform, future work will explore the use of wood-derived sugars as a sustainable carbon source, contributing to the valorisation of lignocellulosic biomass.

The produced structural and adhesive proteins can be subsequently incorporated into composite material formulations with relevance to biotechnology, medicine and alternative protein food applications.

Kewords: protein-based adhesives, mussel foot protein, bacterial curli protein, *komagataella pastoris*, recombinant protein production, wood sugars

29. POLYMER RESINS FROM SUSTAINABLE ORIGIN CARBOXYLIC ACIDS THROUGH THE MICHAEL 1,4-ADDITION

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To promote the transition towards sustainable materials, this research investigates the synthesis of thermoset polymers from renewable second-generation feedstocks — specifically tall oil fatty acids, a byproduct of the pulp industry, and bio-based succinic acid. Through epoxidation and ring-opening reactions with biologically derived alcohols, polyols with a high bio-carbon content are synthesized. Also, succinic acid is used to prepare polyols containing hydrolysable ester linkages, enhancing the recyclability and biodegradability of the final polymers. These polyols are further chemically modified to obtain the two key components required for Michael 1,4-addition: acetoacetates (Michael donors) and acrylates (Michael acceptors). The donors are prepared via transesterification with tert-butyl acetoacetate, while the acceptors are synthesized through acrylation using acryloyl chloride. The resulting multifunctional molecules are specifically designed for room-temperature polymerization, avoiding the use of isocyanates and other hazardous reagents commonly used in conventional thermoset systems. The synthesized donors and acceptors are combined to develop liquid two-component resin systems with varied cross-linking densities. Catalysed by 1,1,3,3-tetramethylguanidine, the formulation cures at ambient conditions, forming rigid and transparent thermoset polymers. These polymers are subjected to comprehensive analysis of mechanical, thermal, and structural properties. This approach offers a promising pathway toward the development of high bio-content resins suitable for use in sustainable composite applications.

Kewords: bio-based michael components, the michael 1,4-addition polymerization, bio-based polymers

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30. A QUANTITATIVE APPROACH TO DETERMINE WATER AND MOISTURE CONTENT IN DIFFERENT TYPES OF LIGNIN USING ATR-FTIR SPECTROSCOPY COMBINED WITH PARTIAL LEAST SQUARES REGRESSION

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Determining water and moisture content is a critical parameter in the characterisation of lignin, as it strongly influences its processing behaviour, thermal stability, solubility, and performance in downstream applications. Lignin, the second most abundant biopolymer in nature and a significant by-product of the pulping industry, is increasingly recognised as a promising renewable feedstock for developing sustainable materials and energy sources. However, the variable interaction of moisture with the lignin matrix complicates its utilisation and necessitates reliable analytical methods. Conventional approaches, such as Karl Fischer (KF) titration, remain the benchmark for accuracy, but the need for specialised reagents, labour-intensive procedures, and extended analysis times constrains them. This study established a reagent-free and non-destructive analytical strategy by combining attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy with partial least squares regression (PLS-R). Reference datasets were obtained from conventional methods, including coulometric Karl Fischer (KF) titration, freeze-drying, and oven-drying at 7 h and 48 h. The acquired spectral data were subsequently used to construct four chemometric models in the OPUS software environment (Bruker, Germany). The models demonstrated high predictive accuracy and robustness, yielding root mean square error of cross-validation (RMSECV) values in the range of 0.53–0.66% and root mean square error of prediction (RMSEP) values of 0.70% (cKF), 0.70% (freeze-drying), 0.33% (oven-drying, 48 h), and 1.0% (oven-drying, 7 h). These results demonstrate that ATR-FTIR-PLSR can serve as a rapid, cost-effective, and sustainable alternative to conventional methods, enabling accurate quantification of moisture/ water in lignin and supporting its broader valorisation in industrial and research applications.

Kewords: lignin, atr-ftir, pls-r, karl fischer titration, moisture content, chemometrics

31. PLYWOOD REINFORCED WITH VOLCANIC FIBRE FABRIC

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Plywood is a widely utilized engineered wood product; however, its mechanical limitations—particularly in tensile strength, bending capacity, and interlaminar bonding—restrict its applicability in high-performance structural contexts. This study investigates the mechanical enhancement of plywood through reinforcement with volcanic rock fibre fabrics (FILAVA™), a sustainable mineral-based material exhibiting high tensile properties and thermal stability. Six distinct fabric, including needle-punched(F), unidirectional(UD), woven(WF), and non-crimp biaxial(BA) types, were embedded between birch veneer layers in one, two , and three-layer configurations using phenol formaldehyde adhesive. The resulting composite panels were subjected to standardized pressing, conditioning, and mechanical testing procedures. Results demonstrated that tensile strength generally increased with fibre reinforcement, with the woven fabric type WF200 yielding the highest value (78.0 N/mm²). The three-layer configurations exhibited the maximum average tensile strength, with improvements up to 23% over unreinforced controls. Additionally, reinforced panels displayed modest enhancements in modulus of elasticity (up to 8%) and modulus of rupture (up to 6%), alongside substantial increases in deflection, particularly in configurations incorporating UD600 and WF600 fabrics. Among the tested variants, WF200 exhibited the most balanced mechanical performance, fulfilling bonding strength criteria and delivering the highest stiffness and strength metrics. These findings indicate the efficacy of volcanic fibre fabrics in augmenting the mechanical performance of plywood, offering potential for advanced structural and fire-resistant applications. Further investigation into fibre-adhesive interfacial behavior and the functional role of fabric architecture is recommended.

Kewords: reinforced plywood, volcanic rock fibre, mechanical properties, composite materials

Acknowledgements: This research work was supported by the Estonian Research Council grant (EAG255).

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32. THERMOPLASTIC STARCH AND MODIFIED AQUATIC BIOMASS COMPOSITES FOR REPLACEMENT OF EXTRUDED FOSSIL-BASED PLASTICS

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Plastics market is constantly increasing since beginning of their mass- production. Unfortunately, most of the plastics are fossil based and due to the limited oil and gas resources there is increasing necessity to find alternative sources for production of plastics, which are obtained from renewable materials. Consequently, this research is devoted to development of fully bio-based composite materials from thermoplastic starch and aquatic biomass components, including carrageenan, extracted from Furcellaria lumbricalis, red algae found in Baltic coast, and lignocellulose, obtained from reed or club rush. Main aim of the research was development of extrudable bio-based thermoplastic composites with tailorable mechanical, thermal, solvent barrier, antimicrobial and other properties. To ensure this, thermoplastic potato starch was used as base matrix material, carrageenan was used as rheology modifier and antioxidant, reed or club rush fibers were used as reinforcing agents to modify mechanical properties of the composites. In some formulations chitosan was added to enhance antimicrobial properties. In some other formulations nanoclay was added to tailor barrier and flame retardant properties of the composite. The composites were obtained by using an ultrasound assisted thermoplastic compounding process and their properties were characterized by FTIR, microscopy, contact angle, water vapor sorption, DSC, TGA, flammability and mechanical tests. It has been demonstrated that at certain proportionality ratios of the above-mentioned bio-based or natural components it is possible to obtain extrudable thermoplastic starch composites with improved rheological, mechanical, thermal and barrier properties.

Kewords: thermoplastic starch, alginate, reed, club rush, composite

Acknowledgements: Valorisation of local aquatic biomass to develop environmentally friendly composite material (AQUABOND) (Nr. RTU-PA-2024/1-0048).

33. MICROENCAPSULATED LINSEED OIL AND COBALT NAPHTHENATE FOR SELF-REPAIRING COATINGS

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The development of self-healing coatings has emerged as one of the most dynamic and rapidly advancing areas in materials science. Self-healing can be accomplished through various methods, with microcapsules being one viable mechanism. In particular, microcapsule-based systems have gained significant attention, with an estimated 200–300 scientific publications on this topic published globally over the past five years. The self-healing mechanism typically relies on the integration of microcapsules loaded with active agents directly into the coating matrix. When the coating sustains damage, these microcapsules break, open and release their contents at the affected site. The released agents then initiate a healing reaction – restoring the coating's protective properties without external intervention. Unsaturated oils are encapsulated and integrated into self-healing coatings because they can crosslink autonomously when exposed to ambient oxygen, eliminating the need for external agents. The healing process can be further accelerated by siccatives, which catalyze the formation of radicals from unsaturated fatty acids. In this study, linseed oil was encapsulated within a polyurea shell via interfacial polymerization, resulting in stable 30-180 m microcapsules with an average shell thickness of 1.5-3.5 m. Additionally, microcapsules containing siccative agent cobalt naphthenate encapsulated in a polycaprolactone shell were prepared using the solvent evaporation method. These stable microcapsules ranged in size from 15 to 100 m, with a shell thickness close to 4 m. The Taguchi experimental design method was employed to identify the key parameters affecting the optimal microcapsule size and encapsulation efficiency. Characterization of the microcapsules was performed using FT-IR, ^{1}H NMR, optical and scanning electron microscopy, as well as thermogravimetric analysis to assess their structural and thermal properties. The impact of microcapsules on the self-healing performance of coatings was investigated. A reduction in notch width was observed in polyaspartic and epoxy coatings containing microcapsules. In the polyaspartic coatings, narrowing occurred with both types of microcapsules tested. Similarly, a decrease in notch width was observed in the epoxy coatings with microcapsules containing only linseed oil as well as those containing both linseed oil and the siccative agent. The largest notch width reduction, up to 93%, was achieved in the coatings with incorporated 5% linseed oil and 2% siccative microcapsules. Additionally, the microcapsule-containing paint exhibited thixotropic behavior.

Kewords: self-healing coating, microencapsulation, siccative, linseed oil

34. A COMPARED STUDY OF ESTERIFIED LIGNIN FOR THERMOPLASTIC APPLICATIONS

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In recent decades, lignin valorisation is gaining attention among scientists due to several reasons, (i) this is the by-product that produced abundantly in paper industry, (ii) the high content of aromatic ring and availability of functional groups in lignin's structure makes it become a promising alternative to fossil-based resources, especially in manufacturing plastic.1 In this study, we compare two distinct esterification pathways of lignin (e.g., kraft and organosolv lignins) and their impact on the composite materials blended with polylactic acid (PLA). Particularly, the esterification was done through (i) hydroxyl groups using fatty acid chlorides (e.g., octanoyl_C8, lauroyl_ C12, and palmitoyl_C16), and (ii) chloromethylation, following by esterification using tetradecanoic acid (C14) and benzoic acid. The blending of resultant materials with PLA was done at three loadings of 10, 20 and 30 (% w/w) by solvent casting method. The successfully synthesized materials were confirmed by FT-IR, and NMR. Thermal characterization includes thermogravimetric (TGA), differential scanning calorimetric (DSC), along with mechanical test were carried out for the composite materials at the highest loading ratio 30% of esterified lignins (C16 via hydroxyls, and C14, benzoic acid through chloromethylation and subsequent organic acid). The results reveal that there is a huge impact on thermal and mechanical properties by the way of how lignin gets modified, specifically the C16-esterified lignin improves the elasticity of PLA due to the plasticization, whereas C14 and benzoic acid enhance the heat stability and the stiffness. To sum up, the study highlights the versatility of modified lignin in tailoring the properties of PLA, which is key to maximizing lignocellulosic biorefineries in general, and lignin valorisation in particular.

Kewords: kraft lignin, organosolv lignin, esterification, pla

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35. INNOVATIVE APPROACH FOR DESIGN OF ROTOR BLADE CORE USING RIGID POLYURETHANE FOAMS

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Like other transport systems, helicopters generate external vibration and noise due to the complex nature of their dynamic systems and suffer from NOx emissions. It is therefore essential that in the design of the new generation of rotorcrafts, these issues are addressed to improve the situation and make them environmentally friendly and acceptable to the general public. The high vibration in a helicopter leads to discomfort for passengers, increases pilot workload, reduces component fatigue life, limits forward flight speeds and increases maintenance costs. Decreasing the vibration of helicopters can effectively reduce fuel consumption at cruise and increase helicopter distance for rescue and law enforcement missions. Polyurethane has the greatest possibility of varying the properties of the final product - the foam material- and thus, combining these properties in a logical order to obtain the necessary material. Changing the properties of Polyurethane foam can happen by changing the polyol/isocyanate ratio, varying the catalysts, varying the blowing agent, affecting foaming with temperature, ultrasound, etc. In this research, the Polyurethane foam polyol component was obtained from renewable and recyclable resources, as well as environmentally friendly catalysts and foaming agents. Polyurethane foams with different densities (30 – 70 kg/m3) were produced with the aim of maximizing the content of renewable and recyclable substances in the ready end-product. To further model the rotor blade core using the finite element method, the density, coefficient of thermal conductivity and compression properties of the produced foam materials was tested. Samples for testing Polyurethane foam were designed in various ways, both with a single density and with varying densities within the test sample. Original methods for tests varying densities have been approved and a database of Polyurethane foams properties has been collected to further calculate the optimal rotor blade core using finite element method.

Kewords: polyurethane foams, density, compression

Acknowledgements: This study was funded by the project "Smart twisting active rotor blades with a functionally graded foam core (SmarTARB)", No. lzp-2023/1-0587.

36. CHOLINE HYDROXIDE-BASED DEEP EUTECTIC SOLVENTS: CELLULOSE DISSOLUTION AND ESTERIFICATION

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Cellulose is the most abundant natural polymer on Earth, noted for its biocompatibility, low-cost, non- toxicity, and versatility. Traditional solvents for cellulose involve harsh chemicals and energy intensive processes. This poses a necessity for research on greener solvents – deep eutectic solvents – to optimize the processing of cellulose. The study focuses on dissolution, regeneration, and esterification of cellulose using deep eutectic solvents (DESs) based on choline hydroxide combined with either oxalic acid or lactic acid. Both dried and undried choline hydroxide were used. The dissolution capacity, physicochemical properties, and structural changes of cellulose were systematically analyzed across varying cellulose concentrations. Rheological analysis revealed that lactic acid-based DESs, particularly when using dried choline hydroxide, possess higher viscosities and more pronounced gel-like behavior than oxalic acid- based systems. Conductivity and pH measurements indicated that lactic acid-based DESs have higher pH and lower conductivity, with ion mobility restricted by structured hydrogen-bond networks. FTIR analysis confirmed that esterification using acetyl chloride and vinyl laurate was not achieved under the tested conditions in both DESs. Structural characterization via NMR and XRD showed that regenerated cellulose largely retained the cellulose I structure, with only partial transformation to cellulose II, and unusually high crystallinity indices (86-91%) attributed to selective dissolution of amorphous regions. These findings highlight the influence of DES composition and choline hydroxide drying on cellulose dissolution and provide insights for optimizing green solvent systems for cellulose in future research.

Kewords: cellulose dissolution, deep eutectic solvents, choline hydroxide, oxalic acid, lactic acid, cellulose regeneration

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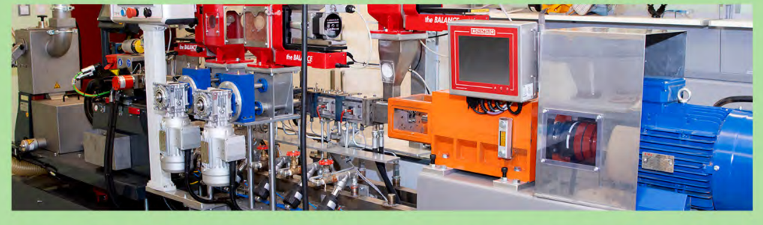

- Equipped with advanced chemical processing tools, our labs facilitate the transformation of wood components into bio-based chemicals and materials.
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