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2nd IPPT_TWINN CONFERENCE

Challenges, trends and solutions in developing and processing biobased products

BOOK OF ABSTRACT

July 2024

FTPO
Faculty of
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EDITORS
Irena Pulko • Blaž Nardin

July 2024

Challenges, trends and solutions in developing and processing of biobased products

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2nd IPPT_TWINN CONFERENCE

Challenges, trends and solutions in developing and processing of biobased products

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Foreword to

2nd IPPT_TWINN Conference

CHALLENGES, TRENDS AND SOLUTIONS IN DEVELOPING AND PROCESSING OF BIOBASED PRODUCTS

Dear reader,

The EU-funded project IPPT_TWINN Reinforcing the scientific excellence and innovation capacity in polymer processing technologies of the Faculty of Polymer Technology (FTPO) is one of the most important projects for the FTPO. The main objective of the project is to increase the knowledge of polymer processing and strengthen the cooperation between FTPO and partner institutions, as well as to improve/enhance the overall research excellence and innovation capacity on innovative polymer processing technologies at FTPO.

Since we know that the amount of polymer materials processed will double by 2030 (up to 650 million tonnes per year), it is crucial to understand what will happen also with the development of biobased products and technologies. So it is no surprise that the 2nd conference under the IPPT_TWINN project is devoted to challenges, trends and solutions in developing and processing of biobased products.

The aim of the 2nd IPPT_TWINN conference is to connect different stakeholders from industry and academia interested in the topic of biopolymer materials and biocomposites, with the focus on challenges, trends and solutions for the present and future of different sectors such as; packaging, automotive, construction, aerospace and furniture.

We have succeeded in addressing the most important issues in the field of biobased products and technologies and attracting the key players in the world of biobased world. The conference will therefore be an excellent opportunity to present and discuss the outstanding issues in biobased products and technologies and to provide guidelines for development of new solutions in this exciting field. The conference is divided into two parts. The first part is dedicated to the presentation of current material developments, industry case studies, and the latest R&D results in different biobased product fields. The second part of the conference will present the scientific results of recycling technologies, supported by 3 plenaries and 4 invited speakers, as well as 9 selected paper presentations.

Main goals are to share knowledge, good practices, ideas and to make new connections between R&D institutions and companies and between different companies in the value chain. With interesting presentations on status and trends, new research findings and innovations, real-life case studies from companies, a panel discussion of experts and B2B meetings we expect to create new partnerships and value chains between and among academia and industry stakeholders.

The strong international participation (9 different European countries) in the conference is proof of its relevance and this is also the guarantee of its success.

Therefore, I would like to take this opportunity to thank all the contributors to the conference, the conference participants and especially the organising team who put a lot of effort into the preparation of this important and solid conference.

Last but not least, I would like to thank the European Commission for funding the IPPT_TWINN project. Without their support, this conference would not have happened.

Assoc. Prof. Dr. Blaž Nardin
Dean of the Faculty of Polymer Technology
Coordinator of IPPT_TWINN project

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14th - 15th May 2024 | Zaragoza (Spain)

Day 1 | Biobased resins and fibers: what to do to reach the industry

9:00 - 9:30	Registration
9:30 - 10:00	Opening Berta Gonzalvo - Aitiip Technology Center, Spain
Session 1: State of the art. General approach to biopolymers	
10:00 - 10:30	**Daniel Schwendemann | OST University of Applied Sciences Eastern Switzerland Switzerland,** Bioplastics, owerview, classification and trends
10:30 - 10:50	**Herfried Lammer | WoodKPlus, Austria** Recycling of biobased fiber composites- from a structural value chain as beneficial raw material to packaging value chain
10:50 - 11:10	**Judit Puskas | The Ohio State University (OSU), Hungary** "Green" Polymers for a Better Future
11:10 - 11:40	Networking coffee
Session 2: The future of biobased materials	
11:40 - 12:00	**Ian Hamerton | University of Bristol, UK** Manufacturing high performance sustainable composites
12:00 - 12:20	**Adrián Moreno | Universitat Rovira i Virgili, Spain** Unlocking the potential of lignin: Towards lignin-based polymeric composites and circular materials
12:20 - 12:40	**Julio Vidal | Aitiip, Spain** Biobased material in complex and recyclable structures
12:40 - 13:00	**Janez Slapnik | FTPO, Slovenia** Challenges and opportunities in the development and processing of short fibre reinforced biocomposites
13:00 - 13:20	**Isabel de Schijver | CENTEXBEL, Belgium** Self-reinforced biobased composites: properties and environmental impact
13:20 - 15:00	Lunch - networking
15:00 - 16:30	**Industrial Round Table** Pablo Martínez (IDEC, Spain) | Pere Castell (GCR Group, Spain) | Iban Ganduxé, Eduardo Martinez (Orzyte, Spain) | Herfried Lammer (WoodK+, Austria) | Prof. Judit Puskas (OSU, Hungary) | Lidia Garcia, Chairwoman (Aitiip, Spain)
16:30 - 18:00	**Match Making** David Ponce | Aitiip Open Training on Research Funding Opportunities

14th - 15th May 2024 | Zaragoza (Spain)

Day 2 | New technological advances in the biobased industry to reach circular economy and meet customer and industry requirements

9:00 - 9:30	**Registration**
Session 1: Bioeconomy certifications and structuring of Territory	
9:30 - 9:50	**Fabio Sagnelli | Bioeconomy expert - BIC Consultant, Italy** Circular Bioeconomy ecosystem for a climate-neutral, sustainable, resilient and competitive Europe
9:50 - 10:10	**Marc Akermann | OST University of Applied Sciences Eastern Switzerland; Switzerland** Welcome in the jungle of bio certificates
10:10 - 11:00	**Round Table: Towards a biobased world** Maider Gómez (CIRCE, Spain) | Maria Díaz (Food+I, Spain) | Ana Carrasco (Paturpat, Spain) | Concha Bosch (AINIA, Spain) | Carolina Peñalva, Chairwoman (Aitiip, Spain)
11:00 - 11:30	Networking - coffee
Session 2: Biomaterial trends in the industry of the future | Papers Pitch |	
11:30 - 11:50	**Blaž Likozar | NIC. Slovenia** Biomass valorization to SSBBD
11:50 - 12:10	**Luka Juvancic | University of Ljubljana, Slovenia** Inedible food waste as source for packaging
12:10 - 13:30	**PRESENTATION OF CALL FOR ABSTRACTS** Matjaž Kunaver | Marisa Fernandez | Bianca Lemes | Irena Pulko | Leyre Hernandez | Silvester Bolka | Rakel Herrero | Marton Tomin | Tamara Rozman | Teja Pešl | Blaž Nardin
13:30 - 13:45	**Closure**
13:45 - 15:00	**Lunch - networking**
15:00 - 17:00	**Visit to Aitiip's facilities**

Challenges and opportunities in the development and processing of short fibre reinforced biocomposites

Janez Slapnik[a]

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In the last two decades, thermoplastic matrix composites (TMCs) reinforced with short lignocellulosic (LCeF) and cellulosic fibres (CeF) attracted high interest from industry and academia as an alternative to TMCs reinforced with conventional fibres (e.g. glass fibres). They offer several attractive properties, such as good mechanical properties, lower CO_2 footprint, renewability, low density, and cost-effectiveness. However, processing of LCeF and CeF reinforced TMCs by twin-screw extrusion also comes with many challenges related to fibres, such as poorly defined properties, difficult feeding, low thermal stability, difficult dispersion and orientation, high moisture absorption, and emissions of volatile organic compounds. The lecture highlights several of the key challenges that compounders face during the preparation of reinforced TMCs and discusses the opportunities to overcome them. The first main challenge is related to the feeding behaviour of fibres, due to the low bulk density and stiffness of LCeF and CeF, resulting in fibre entanglement and poor flowability (bridging), especially in the case of slightly longer fibres. Two main strategies to overcome this issue are discussed: a) increasing the bulk density by pelletizing techniques and b) using special feeding systems. In general, the higher aspect ratio of fibres results in higher stiffness and strength of the composites. It was shown, that in the case of CeF reinforced TMCs, the fibre geometry must be optimised to achieve the desirable properties, as fibres with low thickness lead to poor fibre dispersion, while fibres with a higher initial length lead to high fibre shortening during processing and, with both phenomena resulting in sub-optimal mechanical properties. Due to the relatively low thermal stability of LCeF and CeF care must be taken during the processing of composites reinforced with such fibres. It was shown, that during the injection moulding, TMCs reinforced with LCeF and CeF start to significantly deteriorate their properties at processing temperatures above 220 °C, limiting their use mostly to commodity plastics. In recent years, several strategies for minimising thermal degradation of renewable fibres during melt-blending emerged, enabling LCeF and CeF to be used as a reinforcement of engineering polymers. One approach is to process the TMCs by a one-step process, where fibres are compounded directly on an injection moulding machine (for example by Fibre Direct Compounding process), instead of conventional compounding by twin-screw extruder and subsequent injection moulding. In this way, the thermal load can be decreased. However, single-screw injection moulding machines are significantly less capable in terms of mixing capabilities compared to twin-screw extruders, resulting in poor fibre dispersion and consequently low reinforcing effect. One of the main reasons for the development of renewable fibre-reinforced TMCs is their potentially lower environmental impact compared to conventional composites. Life cycle analysis studies have shown that the production of LCeF and CeF results in significantly decreased greenhouse gas (GHG) emissions compared to the production of glass fibres. However, composites with the latter type of fibres have significantly better mechanical properties. Therefore, a careful examination of the entire lifecycle of the composite components is of paramount importance in order to draw objective conclusions about the impact of renewable fibre-reinforced composite components on the environment.

Keywords: thermoplastic matrix composites, short fibre reinforced composites, lignocellulosic fibres, cellulosic fibres, compounding

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Toughening PLA foams at Budapest University of Technology and Economics: blending and foaming insights

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Biopolymers are advantageous for their environmental sustainability, and through foaming processes, their utility and integration into diverse industrial applications can be significantly enhanced [1, 2]. In the light of these industrial trends, our research study at the Budapest University of Technology and Economics focused on the toughening of poly(lactic acid) (PLA) through blending, particularly with poly(butylene adipate-co-terephthalate) (PBAT) and poly(butylene succinate) (PBS). We conducted drop weight tests on the materials to evaluate their energy absorption capabilities, which are crucial for understanding the toughness enhancement achieved through blending.

Atomic force microscopy (AFM) was employed to substantiate the trends observed in the material's behavior, revealing the morphological reasons behind the toughness enhancement. The AFM images confirmed the formation of a co-continuous structure in the 50/50 blends of PLA/PBAT, explaining the synergistic improvement in the perforation energy observed in these samples. In other mixture ratios, a droplet structure was observed.

After establishing the fundamental toughening mechanisms through blending and drop weight impact testing, we proceeded to examine how these biopolymer blends could be foamed using expandable microspheres (EMS). The foaming process was investigated to determine its effects on the microstructure and mechanical properties of the resulting biopolymer foams. Scanning electron microscopy (SEM) was utilized to assess the cellular structure of the foams, with a focus on how the quantity of EMS influenced the cell size and distribution.

In addition, impact testing of the foam samples was also conducted, where the toughening effect was also evident; as the blends demonstrated superior performance compared to the unblended PLA foams. This enhancement suggests that with further optimization, biopolymer foams hold significant promise for broader application in various industries, leveraging their environmental benefits.

Keywords: biopolymers, poly(lactic acid) (PLA), toughening, foaming, energy absorption

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Mechanical and thermal properties of biocomposite reinforced with coconut fibres based on PLA and recycled PE-LD matrix

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Commercially available, biodegradable PLA is the first choice as a solution for the circular economy in many sectors, including very often for packaging. Bio-based and biodegradable thermoplastic matrix or biocomposites with recycled thermoplastic matrix are becoming increasingly important in plastics processing, mainly because of their lower carbon footprint and, in the case of recycled thermoplastic matrix, because of the focus on the circular economy. The circular economy is particularly effective when implemented locally, i.e. the raw material for the biocomposite is sourced locally, where the biocomposite is then compounded and further processed into the final product. In order to improve the strength and maintain the toughness of the biocomposite as much as possible, good interfacial interactions between the thermoplastic matrix and the added natural fibres must be ensured. The first option is surface modification of the natural fibres, where the treatment of coconut fibres with chromium sulphate and sodium bicarbonate has improved both mechanical and thermal properties [1]. The second option is the use of a compatibilizing agent in the compounding process. A thermoplastic elastomer has been shown to be an excellent compatibilizer between coconut fibres and a non-polar thermoplastic matrix, which interacts well with the surface of the coconut fibres (lignin) via its functional groups (isocyanate groups) [2].

In our study, we decided to use a thermoplastic elastomer as a compatibilizer based on maleic anhydride graphitized styrene-ethylene-butylene-styrene (SEBS-g-MA) and two different thermoplastic matrices, namely rPE-LD and PLA. The mechanical and thermal properties were investigated using the Universal Testing Machine (UTM), Differential Scanning Calorimetry (DSC) and impact tests. The viscoelastic behaviour of these composites was investigated using dynamic mechanical analysis (DMA). As different plastic processing technologies were used to manufacture the end products, the melt flow index was also measured. By adding 20% coconut fibre production waste to the PLA matrix, a high MFI is maintained, and with a high stiffness of 2.9 GPa and a strength of 64 MPa, the impact strength is still 11.6 kJ/m2. The addition of 50% coconut fibre production waste to the recycled PE-LD matrix practically does not change the MFI, the stiffness increases from 0.2 GPa to 0.7 GPa, the strength is 12 MPa, the impact strength is still excellent despite the addition of 50% coconut fibre production waste, and the test specimens do not fail during the test. The melting points of the composite are between 110 °C and 123 °C for PE and 159 °C for PP impurities. We succeeded in extruding packaging nets and hollow tube profiles with PLA-based biocomposite and hollow tube profiles with biocomposite. Thanks to a suitable compatibilizer, which simultaneously improved the inter-surface interactions between the coconut waste fibres and the thermoplastic matrix (both rPE-LD and PLA) while significantly increasing the toughness of the resulting biocomposites, we were able to increase both the stiffness and the strength of the biocomposites, while the toughness remained at a very high level.

Keywords: thermoplastic biocomposites, compatibilizer, coconut fibres, mechanical properties, thermal properties.

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Mounting key as use-case for up-cycled thermoplastic composite with waste thermoset composite

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100% recycling of any material is practically unattainable, and leftover material must be disposed of in landfills. Legislation increasingly favours recycling. The waste management system should focus on various recycling processes to recover energy from hydrocarbons or reuse them as secondary raw materials (recycled materials). By using different recycling techniques for thermoset composites, the reinforcing fibres can be recovered. Recycled composites are also cheaper than using virgin reinforcing fibres [1].

Glass fibre and carbon fibre reinforced polymer composites have revolutionised important production sectors such as transportation (cars, airplanes, boats) and construction (buildings and infrastructure, plants, wind turbines) due to their lighter weight and better corrosion resistance compared to metals. The market for composite materials is dominated by glass fibre reinforced plastics in terms of volume. Therefore, the development of sustainable circular economy solutions for the end-of-life management of composites is one of the most important challenges for the modern plastics industry. Recycling is the most studied solution for sustainable end-of-life management of composites. Existing recycling technologies and methods are mechanical, thermal or chemical recycling [2].

In this article, we present a good practise example of circular economy from Slovenia. We used a waste thermoplastic composite reinforced with a waste thermoset composite. To combine the good properties of both materials, we added a compatibilizer to achieve compatibility between the two recyclates.

The thermoplastic composite material was production waste from OPS Breznik, the thermoset composite material (discarded wind blades) was sent to us in ground form by Politechnico di Milano. For the purpose of characterization, we performed compounding on a twin-screw extruder, adding 30 wt.% of the thermoset composite waste and 0.5 wt.% of the compatibilizer to the recycled thermoplastic composites. The prepared recycled thermoplastic composite was injection moulded and then tested for its mechanical and thermal properties. To test the manufacturability, a larger amount of the mechanically recycled thermoplastic composite was produced and more than 100 pieces of prefabricated water filter keys were injection moulded and then laser engraved.

The effect of adding 30 wt.% recycled thermoset in ground form to a recycled thermoplastic composite based on PA 66 reinforced with 15% glass fibres was investigated. Based on the results of the TGA analyses, it was found that only half of the glass fibres are present by weight in the recycled thermoset composite, while the remainder consists of the thermoset matrix, which acts only as a filler and not as a reinforcing agent. The results showed an increase in strength and stiffness of approx. 60 % and 20 % respectively. The elongation at break decreased by 15 %. The main objective of the study, the addition of a recycled thermoset composite in ground form to a recycled thermoplastic composite based on PA 66 reinforced with 15% glass fibres and made compatible with small amounts of added compatibilizer, was successful.

Figure 1. Injection moulded mounting key from up-cycled thermoplastic composite with thermoset composite, with laser engraved DeremCo project logo

Keywords: thermoplastic composites, thermoset comosites, recycling, compatibilizer, properties.

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Rails for ski bindings as use-case for up-cycled thermoplastic composite with waste thermoset composite

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The recycling of polymers is becoming increasingly popular, mainly due to the rising cost of virgin polymers and, more importantly, the impact on the environment. Recycling allows companies to reuse waste and bad products, thus reducing the cost of the final products. At the same time, it is important to be aware that material properties change during mechanical recycling, so the recyclate cannot be used on its own, but is mixed with virgin material in a certain ratio. If 100% recyclate is used, upcycling must be used to restore the mechanical properties [1]. For highly filled thermoplastic composites, a higher fibre content increases the fracture and fatigue strength of the composite. A high proportion of reinforcing fibres entails the risk of agglomeration. With a high proportion of reinforcing fibres in thermoplastic composites, the fibres rarely pull out at break, but rather break. Failure of thermoplastic composites usually starts at some distance from the fibre in the matrix and not at the fibre-matrix interface. The damage begins in the form of cavitation in the matrix around the submicron particles. The cavities fuse and cause microcracks in the matrix. The initial position of the crack is strongly influenced by local stress concentrations due to fibre-fibre and fibre-matrix interactions. The description of the fibre distribution around the notches is therefore a fundamental step for the development of a model to predict the lifetime. Microcracks in the matrix lead to the formation of a crack that propagates in an avoidance mode, bypassing the fibres at a certain distance from the interface so that the fibres remain covered by the matrix layer [2].

In this paper, we present the use of Turnaplast's industrial recyclate PA6 GF50 to which we added ground thermoset composite waste. In order to achieve a good interfacial interaction between the PA6 matrix and the milled thermoset composite waste, we used a combination of compatibilizers to achieve an optimal combination of stiffness, strength and toughness. Given the high proportion of added reinforcing fibres, compounding trials were also carried out with added slip agent to reduce the shear stresses during processing caused by the reduced pressure during injection moulding.

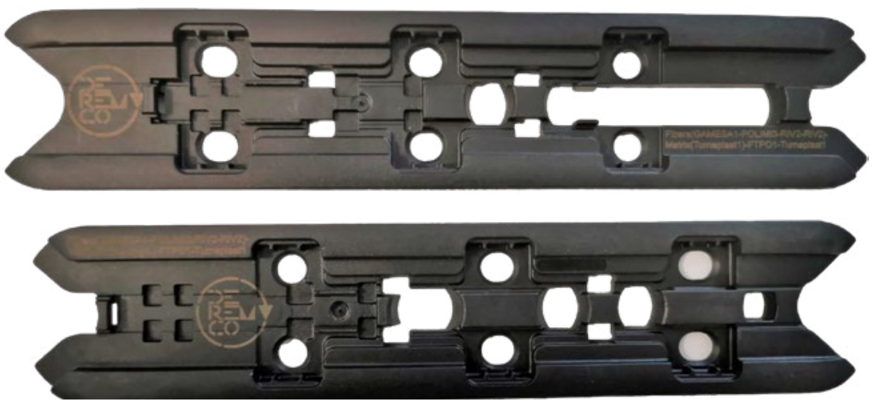

Figure 1. Injection moulded rails for ski bindings from up-cycled thermoplastic composite with thermoset composite, with laser engraved DeremCo project logo

Keywords: thermoplastic composites, thermoset comosites, recycling, compatibilizer, properties.

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5-HMF-based phenolic resins

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One of the ways to ensure sustainable development is the use of renewable natural materials, such as biomass. In the field of polymers, development mainly takes place in three directions namely, modification of natural polymers (starch, cellulose), preparation of polymer composites using natural fibres and biomass, decomposition of biomass, especially cellulose and lignin into chemicals that can be used for the synthesis of polymers. Through the chemical decomposition of cellulose, which is the most abundant renewable source of carbon on the planet, we can obtain raw materials for the production of various valuable molecules and bio-based polymers. These are mainly various furans, polyols, 5-hydroxymethyl furfural (5-HMF), organic acids (levulinic, formic,...) and other molecules.[1]

5-HMF seems to be an interesting starting chemical or monomer for the production of bio-based polymers, although not many of them were synthesized. Polyethylene furanoate (PEF) is probably the most interesting and developed one, and it is expected to replace PET one day.

5-HMF could also be used as a substitute for formaldehyde in phenolic resins. The synthesis was performed at a phenol/5-HMF ratio of 1/0.95. Various acidic catalysts were used, and the time of reaction was varied. When strong acid was used the product was a mixture of solid and liquid products. The solid one was insoluble and therefore crosslinked polymer. When mild catalysts were used, the product was a dark brown, almost black, viscous liquid, which was characterised by FTIR, NMR, DSC and TGA. The glass transition temperature (Tg) was observed at approx. -17 °C. Obtained polymer was crosslinked by hexamethylene tetramine, which is also used as a curing agent for novolak phenolic resins. Crosslinked polymers with a glass transition temperature of up to 100 °C were obtained. In the end, biobased composites with cellulose fibres (paper) were prepared and thermomechanical properties were determined by DMA.

Keywords: 5-HMF, phenolic resin, TGA, NMR.

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Residential paints enhanced with nanocrystalline cellulose additives (CNC)

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Masonry and wood, being porous and hygroscopic substrates, are susceptible to humidity, weather, and UV radiation. To protect and enhance their durability, coatings like building paints and varnishes are commonly employed on facades and openings.1 With a growing emphasis on reducing volatile organic compounds (VOCs) and adopting water-based systems, along with materials from renewable sources, biomass-derived materials like microcrystalline cellulose (MFC), nanofibrillated cellulose (CNF), and nanocrystalline cellulose (CNC) offer versatile and environmentally friendly alternatives to traditional fossil or synthetic sources.[2]

In view of this, this work aims to investigate the influence of CNC on certain percentages in the formulation of real estate paint coatings, which comply with current regulations according to the ABNT NBR 15079-1:2021 standard, establishing the minimum performance requirements for latex paints.

In the coating formulations, formulations from the Economy and Premium lines were selected, using two CNC solids contents: 0.15% and 0.30% of the total formulation by weight. These formulations were compared with paint without the addition of CNC, called reference paint. CNC was used in suspension and added under stirring to the paint formulation. It was found that the addition of CNC did not change the aesthetic characteristics of the coatings, meeting the performance requirements of the standard and maintaining the paint properties in accordance with the reference paint. Furthermore, it promoted a reduction in the percentage of thickener use, a reduction in system brightness, greater resistance to abrasion and UV exposure compared to the reference paint without the use of CNC.

The analysis of the results promotes and enhances the use of CNC in building paints as a raw material of renewable origin that improves certain performance properties and introduces a versatile raw material to the paint market, in addition to contributing to a reduction in water use in the formulation.

Keywords: Residential paints; nanocrystalline cellulose; coating; paints; renewable

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New materials and manufacturing technologies for carbon footprint reduction in automotive applications

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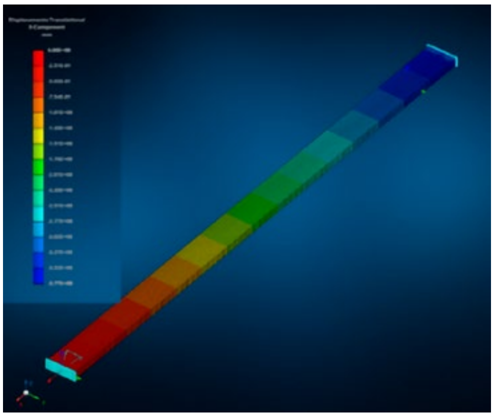
The automotive industry is under high pressure to meet increased fuel efficiency, environmental friendliness, and energy efficiency at competitive costs. All industries of plastics, as well as steel, aluminium and magnesium, are operating to respond to the demands of the automotive industry on the changing needs that are emerging. The use of composites in automotive manufacturing has been increasing due to the advantages they bring. Automotive composites, reinforced plastics and polymers are among the preferred alternatives to lighten the weight of the automobile, as they offer improved properties such as impact resistance, ease of molding, improved aesthetics and reduced weight compared to conventional components.

Alternative materials such as composite, as well as new fabrication technologies such as 3D printing of Continuous Fiber Reinforced Composite (CFRC), have emerged as promising alternatives in the field of manufacturing, offering numerous advantages compared to other conventional techniques. This innovative technique enables the production of highly customised and complex composite parts efficiently and accurately. Structural simulation plays a crucial role in ensuring that lightweight design strategies in the automotive sector are successful. It helps engineers make informed decisions about materials, design choices, and manufacturing processes, ensuring that lightweight components meet safety, performance, and cost requirements. Structural simulation allows to analyze how lightweight materials, such as advanced composites, will perform in vehicle components. Simulating stress, strain, stiffness, dynamic behavior, life prediction it is possible to predict if these lightweight materials meet safety and performance requirements. The comparison of composites from non-renewable sources and bio-based composites offers very important information on the possibilities of switching from one to the other to obtain more environmentally friendly components.



In this project we investigate new bio-based materials and new manufacturing technologies such as 3D printing of composites to manufacture lightweight automotive components. Panels have been manufactured by vacuum infusion using recycable resins and reinforcing materials of natural origin and their mechanical properties have been compared with panels manufactured using conventional materials. In addition, new filament formulations based on bio-based materials are being developed for the manufacture of automotive components by 3D printing of composites. Simulation of manufacturing processes using tools such as APEX Design Generative - MSC Hexagon are also being developed

Keywords: biobased composites, 3D printing, simulation, lightening, automotive.

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Cover for mulcher as use-case for up-cycled thermoplastic with waste thermoset composite

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Polypropylene (PP) is often physically modified with fillers to reduce the price and increase stiffness and strength. Improving the interfacial adhesion between the fibres and the PP matrix is a key research topic, as the interfacial adhesion between fibres and PP plays an important role in determining the properties of the composites [1]. The pressure on environmental protection can be reduced and the idea of converting waste materials into valuable composites can be realised. Research has been reported on the treatment of thermoset composites from waste and various compatibilizers for composites with natural fibres [2]. Recently, the recycling of PP has also become an important issue as the amount of PP in municipal thermoplastic waste is increasing. PP as a packaging material has played a major role. Polypropylene grafted with maleic anhydride (PP-g-MA) as a compatibilizer facilitates dispersion and improves the surface bonding of fibres in the matrix of recycled PP (rPP). The fibres promote crystallisation and improve the strength, stiffness and toughness of the fibre rPP composite [1].

The aim of this study is to improve the strength and stiffness of rPP by modifying the matrix with additives and thermoset composites made from waste. Thermoset composite waste materials were shredded and ground. A variety of thermoset composites were tested to determine the effects of composition, size and ratio of glass fibres and thermoset resin on the properties of thermoplastic composites with recycled PP matrix. The mechanical, thermal and rheological properties of these composites were studied in detail and compared with those of PP recyclates. Finaly, with the selected version of waste thermoset composite, bigger amount of thermoplastic composites were compounded with 30 wt.% addition of of waste thermoset composites.

Keywords: thermoplastic, thermoset comosites, recycling, compatibilizer, properties.

Figure 1. Injection moulded cover for mulcher from up-cycled thermoplastic with thermoset composite, with laser engraved DeremCo project logo

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Co-creating strong uptake of remedies for the future of our oceans through deploying plastic litter valorisation and prevention pathways

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REMEDIES project acts as a lighthouse at Mediterranean Sea basin scale and is connected to the EU Mission: Restore our Ocean and Waters. [1] The outputs will demonstrate scalable breakthrough innovations (technological, business, social and governance) to prevent and minimize marine plastic pollution at 8 demo sites and a lighthouse. Moreover, REMEDIES will support, with mentoring, coaching and financial resources, regions to boost the deployment of plastic litter collection and valorisation schemes as well as to push towards the development of zero-waste supply chains through five grants for associate regions. [1]

The first pillar is detecting and monitoring marine plastic litter. The four technologies and innovations used in this pillar are: AI-enabled drones, underwater drones, fluorescent dyes and automated microscopic detection as well as development and use of a marine litter-monitoring app and a dashboard. [2]

The second pillar is revolving around marine litter collection and valorisation from at least 80% of identified plastic litter types. We will establish plastic litter valorisation strategies for fishing gear, microplastics, marine litter collected and collection of the (bio)plastics at the events co-organised by REMEDIES partners. The four technologies and innovations used in this pillar are: plastic collection and valorisation through citizen science, river cleaning technology, microplastics filtrations for washing machines and marinas, and clump and skim technology. [2]

The third pillar is the prevention of the distribution of non-degradable plastics and zero waste solutions, by avoiding single-use plastic items, developing zero-waste workshops and solutions across all demo sites and replication cities. The four technologies and innovations used in this pillar are: anti-litter campaigns and zero plastic waste solutions, biodegradable fishing gear, zero-waste cups and bottles, and zero waste natural cosmetics for tourism. [2] Through collaborative, participatory methodologies and citizen science activities engaging the stakeholders to act, learn and contribute to a plastic litter free future the project will pave the way towards a more plastic-conscious society.

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Keywords: EU Mission: Restore our Ocean and Waters; REMEDIES for ocean; plastic litter valorisation; citizen science

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Nanocrystalline cellulose from laboratory to pilot plant production and its use

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A highly efficient and eco-friendly procedure for rapid preparation of nanocrystalline cellulose (NCC) from biomass was developed and optimised[1]. It was achieved by liquefaction of amorphous part of cellulose, lignin and hemicelluloses in diethylene glycol under acidic catalysis. The feedstock can be any cellulose containing biomass or its waste.

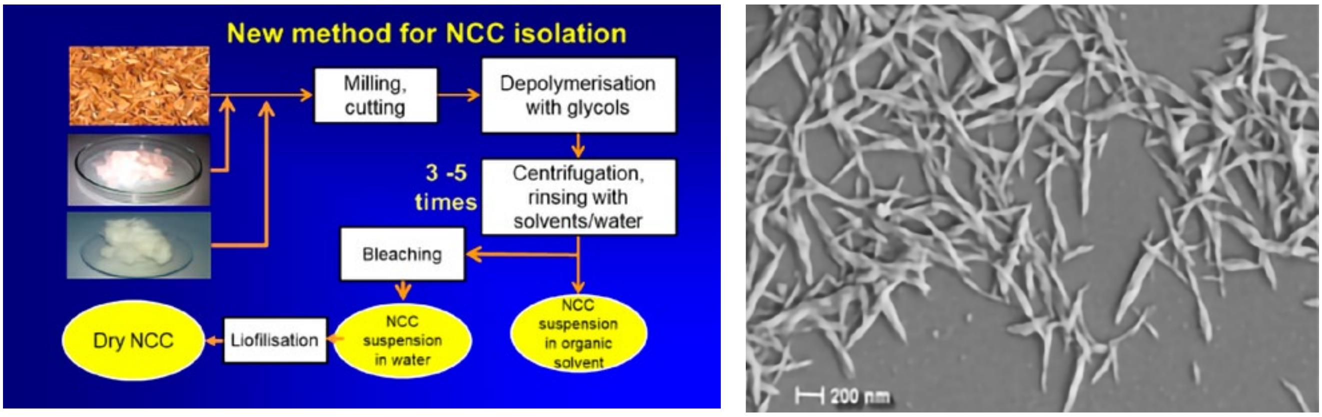

Figure 1. Left: schematic diagram of the NCC production; Right: SEM micrograph of NCC

Lignocellulosic biomass was dispersed in glycol and methane sulfonic acid (3%) was used as a catalyst. The NCC was isolated as a residue, rinsed with a mixture of glycol and water and centrifuged. The product was a NCC suspension in water or any polar organic solvent. The crystallinity index was from 75% to 84% and the yield was more than 67% when using cotton as the starting material. The average particle size was between 200 nm and 500 nm, with diameter from 15 nm to 30 nm. The method was also tested in the pilot plant reactor with 250 lit capacities. The pilot production was further optimized by using liofilization for production of dry NCC. Thus produced NCC was used in water based acrylic coatings improving the scratch resistance, as reinforcement in different polymer composites increasing the mechanical strength, in packaging films enhancing the barrier properties and in paper production improving the printability and more important – decreasing the water vapour permeability. The LCA analysis proved the eco-friendliness of the process since the impact on the environment is much reduced if compared to well establish methods[2].

Keywords: Nanocrystalline cellulose production.

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Biodegradable materials as strategy to prevent the pollution in Ebro River

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Littering, plastic and microplastic pollution of water, including rivers, groundwater, and oceans, has become a big concern for the authorities and society in general since it is expected to nearly triple by 2040 the quantity of plastic wastes in marine water areas [1], growing the threat in all ecosystems. Therefore, implement efficient strategies to reduce this tendency is a priority for the European Commission, who launched the specific EU Mission 'Restore our Ocean and Waters' to protect and restore the health of our oceans and waters through research and innovation, citizen engagement and blue investments [2].

The Ebro River is one of the most important rivers in Spain in terms of length (928 km), and area of drainage basin (85550 km 2). The Ebro River flows through the north and northeast of the Iberian Peninsula, discharging into the Mediterranean Sea, and according to recent publications [3], it annually contains and dumps more than 2 billion microplastics into the sea. Currently, it is difficult to remove small particles or microplastics (fragments from 0.1µm to 5mmin diameter) [4] mechanically in wastewater plants, and the conventional small particles and microplastics can persist in the environment for long periods of time increasing the environmental impacts and degrading the water ecosystems.

In this context, UPSTREAM [5] project is based on the widespread deployment and demonstration of a suite of advanced solutions that address the serious issues of pollution from litter, plastics, and microplastics in European rivers along 5 pillars – monitoring, prevention, elimination at wastewater treatment plants, elimination from rivers, and valorisation of collected plastics. Focused on the pollutant prevention in Ebro River, UPSTREAM project proposes the development of new biodegradable materials as a strategy to prevent the plastic and microplastics pollution. In this sense, main actions have been focused on the production of new polymeric blends and subsequent plastic products (e.g food packaging, cutlery) to significantly reduce their lifetime in freshwater (in case they reach river by accidental littering), and hence, reducing the overall environmental impact and safeguarding the water quality and ecosystems.

Keywords: Biodegradable, prevention, microplastics, Ebro-river, UPSTREAM-project

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Challenges, trends and solutions in developing and processing of biobased products

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