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Mechanical characterization of a PHA bio-composites based on natural Alfa fibers

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Novel numerical anatomy-based modelling of bamboo microstructure

Abstract

This study presents a novel anatomy-based numerical bamboo microstructure analysis that accurately and inclusively represents the material geometrical features and compare that with literature's state-of-the-art numerical and analytical approaches in terms of the effective elastic properties estimation. Bamboo is one of the materials that have recently attracted considerable interest in sustainable buildings as they are fastest-growing, retaining mechanical properties similar to structural wood products, and considered effective CO2absorbers. Experimental studies that investigated bamboo properties mainly were limited to the coupon scale. Several studies tried to estimate the material properties and their behaviour using homogenisation methods, both analytically and numerically. However, due to restricting assumptions and simplification, studies to date did not consider detailed modelling and analysis of the material's microstructure. Hence, this study develops a numerical anatomy-based that captures the material features. The effective stiffness properties of this representation along with the models found in the literature, are estimated and compared. It is concluded that conducting anatomy-based numerical is feasible and provides a better understanding of the material microstructure and its corresponding effective stiffness properties.

Keywords: Bamboo; RVE; Bio-Based Composites

Biography

Layth S. Al-Rukaibawiis a second-year doctoral student at Budapest University of Technology and Economics. He received a bachelor's degree in building and construction management from University of Technology in Baghdad, Iraq and a master's degree in Structural Engineering from Newcastle University in England, United Kingdom. His current field combining his interests in mechanical testing and Finite element Analysis in the context of Moso bamboo-based Composite materials for buildings and wind energy sectors.

Mengstu Asherbe Arefe, Mulualem G. Gebregiorgis, Aart W. Van Vuure

Physical and Morphologic Properties of Enset Fiber and effect of surface treatment

Abstract

Enser fiber is a new fiber that has been extracted from enset verticosum.The fiber is a by-product of starch rich food locally called KOCHO. The aim of this paper is to study physical properties and structural appearance of enset fiber and the effect of fiber treatment on the physical and morphological properties. A new approach has been designed to determine its density of the fibre: image has been taken from light microscope and examined with graphic software. Comparison has been made with Helium-pycnometer. Moreover, the diameter of the fiber has been determined by direct weighing of the dry fibers and dimeter measured from density, length and weight with the assumption that fibers possess circular shape. Alkali and acetylation treatments have been taken place to examine effect on the water carry capacity of the enset reinforced composites and the effect on the microstructure. Results showed that the density of the solid part of the fiber using morphologic image and pycnometer provide 1.464 g/cc and 1.456 g/cc, respectively. Taking this as an important validation, the overall density of the mechanical fiber is found 0.89 g/cc. Approximating the fiber possessing circular shape, the averaged value of the diameter is reported as 76.05+17.68 µm fiber diameter. Taking a dominant technical fiber as inference, we found that the areal/volume contribution of cell wall of the elemental fibers, the central lamella and the lumen in the technical fibers are found as 51.45%, 9.09% and 38.55%, respectively with total area of 1.0168*10-2 mm2. The structural shape of mechanical fibers can be approximated as curved cylinders and elemental fibers as circular shapes with averaged diameter of 15 µm. The water molecules carrying capacity of the fiber found as 41.54% and 11.05% for untreated and alkali treated fibers with one dimensional Fickian diffusion coefficient of 0.522 and 0.168mm2/√Hrs, respectively. The desorption analysis showed a total removal of the water contents from the composite samples when drying in oven at 600C for 16 days. The alkali treatment has brough a big change on the lumen part, diameter and the microstructure of the fibers.

Keywords: Physical properties, Morphologic properties, Fiber treatment

Mahadev Bar, Pierre Ouagne

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Refining of Vegetal Fibres Through Emulsion Treatment

Abstract

Public's growing awareness on sustainability and the demand for more environmentally friendly products have bolstered the interest in bio-based materials in the consumer industry. Use of vegetal fibre as a substitute of their synthetic counterpart for textile, rope and in other applications fits well with this trend. Vegetal fibres are obtained from the fibre rich parts of the plant such as from stems, leaves, fruits etc. Most of the vegetal fibres are multicellular and are available in bundle form. Following their initial mechanical extraction, the vegetal fibres are coarse and need to be refined before transformation into textile yarn or technical textiles. Various mechanical actions such as carding, gilling, combing etc. or chemical treatment such as alkali treatment, acid treatment etc. or physical treatment such as treatment with corona, plasma, ultrasound etc. or their combinations are generally employed for the refining of vegetal fibres. However, some of the above processes damage the extracted fibre while some others are not environment-friendly. Hence to avoid the above issues, we have refined some vegetal fibres (dry-coarse banana and Hemp) in a novel way. In this approach, an emulsion is applied over the dry coarse vegetal fibre and is conditioned for 48 hours while covering with a polymeric sheet. The conditioned fibres are then subjected to a mechanical carding or combing process with the aim of fibre refining. In the case of banana fibre refining, a mineral oil-water based emulsion is used for the fibre conditioning purpose. It is observed that the banana fibre refined through this novel approach has higher crystallinity, tensile properties, thermal stability, moisture content, and brightness than that of untreated fibres and the fibres extracted through other treatments such as alkali treatment and acetic acid treatment. On the other hand, three bio-based emulsions were used for hemp fibre conditioning purpose. The conditioned fibres are then refined using a lab-scale fibre hackling device. It is observed that the emulsion treated fibres have fewer numbers of kink-band defects on the fibre surface which resulted in superior mechanical properties of the emulsion conditioned fibres than that of unconditioned one.

Keywords: Vegetal fibre, Emulsion treatment, Fibre extraction

Biography

Dr Mahadev Bar is a postdoctoral researcher at the Laboratoire Génie de Production, LGP, Université de Toulouse (INP-ENIT), Tarbes, France. He joined the bio-composite and textile group at ENIT lead by Professor Pierre Ouagne in January 2019where he involved in the research work of different projects such as SSUCHY, NABITEXetc. and also in the research work of some PhD, masters and internship students. Prior to join his post-doctorate Mahadev has received his bachelor degree (B. Tech) in Jute and Fibre Technology from the Department of Jute Technology, University of Calcutta, Kolkata, India, in the year 2010;Master's Degree in Fibre Science and Technology and PhD in Natural Fibre Based Hybrid Yarn Reinforced Thermoplastic Composites in the year2012 and2018respectively from the Department of Textile Technology, Indian Institute of Technology Delhi, New Delhi, India. In between his Master's and PhD, Mahadev worked as a Senior Research Fellow in a CSIR sponsored project in the Department of Textile Technology, IIT Delhi for one-year. The research thematic spectrum of Mahadev covers the fibre extraction from nonconventional plant resources, textile preparation and manufacturing, the characterization and the recycling of plant based technical textile products from which bio-composite materials are the main part. In his short research carrier, Mahadev has published 14research papers in different international peer-review journals and more than 10 papers in international conferences proceedings. He also wrote three chapters in the book published by different international publishers.

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Wood-based biomaterials development: why volatile organic compounds can be relevant indicators

Abstract

Volatile Organic Compounds (VOCs) emissions have been studied since a few decades, as they affect human health, and regulations are regularly implemented to reduce these emissions. VOCs are known to be released by petrochemical adhesives, like urea-formaldehyde, which is used for the production of most of the industrial wood-based panels. These panels then emit VOCs throughout their lifetime. To prevent VOC emissions, boards without any resins can be manufacture by using own adhesive properties of the raw material. Different biomasses have been investigated as raw material of binderless boards, comparing mechanical properties of these boards. VOC emissions from binderless boards have rarely been studied. The aim of this work was to study how the emissions of VOCs from binderless boards can be an indicator to find the optimal thermopressing conditions. Binderless boards have been made from either heartwood, sapwood or sawdust from oak (Quercus robur), following a design of experiments, varying the pressing temperature (129-211 °C), the pressing time (1-11 min) and the moisture content of the raw material (7-17 %). After placing the boards in environmental chamber (23 °C, 50% RH), VOCs were trapped in Tenax TA® tubes, DNPH cartridges and SPME fibres. They were then analysed by GC-FID, GC-MS and HPLC/DAD for identification and quantification. Some VOCs were especially measured i.e. total volatile organic compounds (TVOCs) and formaldehyde, both according to the NF EN ISO 16000. Wood degradation products were specifically monitored as indicators of thermopressing severity. Results have shown that for boards made from heartwood, VOCs emissions including those of acetic acid, furfural, 3-furaldehyde and TVOCs were directly correlated to process parameters, especially pressing temperature and time. These trends were also observed for the boards made with the other raw materials. Relationships between emissions and mechanical characteristics of the boards i.e. flexural strength and internal bonding, estimated according to the NF EN 310 and the NF EN 319 respectively, were also investigated.

Keywords: VOC, binderless boards, Quercus robur

Biography

Elise Bertheau studied wood science at the "Ecole Nationale des Technologies et Industries du Bois" (ENSTIB), Epinal, France. She strengthened her skills during internships in a biotechnology company, Vandoeuvre-les-Nancy, France and in a Regional Centre for Innovation and Technology Transfer of Wood ("CRITT Bois"), Epinal, France. After obtaining her engineering degree from the ENSTIB, she started a PhD thesis in November 2019 at the "Laboratoire de Chimie Agro-industrielle" (LCA), Toulouse, France, with the aim of studying the impact of water on VOC emissions in thermo-mechanical-chemical processes related to biomaterials elaboration, under the supervision of Dr. Valérie Simon and Dr. Christine Raynaud.

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Biography

In 2017, I graduated from a two-year university degree in chemical and process engineering from the University of Caen. At the end of the two years, I did an internship in a plastic company. I really appreciated the way polymers are malleable and shapeable and how the process is so simple in its complexity. So to learn more about the subject, in the summer 2017,I decided to start my first year of engineering school at ISPA in Alençon, Normandy. This school is exclusively in apprenticeship and is specialized in polymers and composites materials. During the three years of diploma I worked half the time in an automotive company in the R&D department, I also had the chance to do an internship in a foreign country in a research laboratory in Aachen, Germany. This background from those two experiences did that I have been attracted by the research field more than other topic. That is why I decided to continue my studies as a PhD student. I was looking for a subject closer from my moral value and beliefs and I am proud to work on such a project and such a team that focuses their energies to look for environmental solutions.

Development of innovative eco-materials based on plant and agro-sourced polymers

Abstract

The objective of the thesis is to develop two types of agro-composites, cementitious matrix composites and organic matrix composites. The pathway to develop these agro-materials is similar. The constituents used for their formulation come from flax by-products or industrial wastes as oilcake, mucilage and different types of fibre such as shives. The thesis is divided into three major steps: the first is the biochemical characterisation of all the components that will be used in the development of the composites, the second concerns the development and research into the formulation of the composites as well as their mechanical, thermal and hydric characterisation. Finally, a decision support system could be set up in order to develop the best formulation possible and to study the interactions between raw materials/processes/agro-materials, depending on the targeted application. A special attention will be paid to polysaccharides and proteins contained in flax by-products and industrial wastes. With regard to cementitious composites, polysaccharides may result in a setting delay or viscosity improvement. Animal proteins can induce a foaming and viscosity modification. So, how will these flax polymers act as admixtures? How will their composition and structure impact composites properties? Furthermore, polysaccharides or protein biopolymers can be modified using an in situ process based on horseradish peroxidase (HRP) to obtain a three-dimensional structure. The crosslinking will be done via phenolic functional groups by the enzymatic reaction with HRP. Thus, the natural presence of phenols in the mucilage is an advantage in the realisation of thermocompressed composites. The elaboration of functional materials by 3D printing of modified polysaccharides will also be considered. The 100% biosourced approach would make it possible to study the biochemical interactions between the matrix and the by-products of the flax plant (shives). The agro-composites developed will be of great interest to replace petroleum-based matrix or admixture in materials for housing, transportation and packaging purposes. As the thesis has only been in progress for a few months, no results are yet available concerning the composites themselves. We currently closed the first step of the project: components characterisation.

Keywords : Bio-based composites, Formulation, Characterization

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Development of a hybrid Lignin/TEOS coating for the protection of 2024 aluminum alloys used in the aerospace industry

Abstract

In the current context of anticorrosion technological developments in the aeronautical sector, new alternatives to usual products, such as hexavalent chromium, are being studied and are intended to be more eco-sustainable, as expected by current legislation. In this context, a new approach to the protection of 2024 aluminum alloys has been initiated with the development of innovative hybrid coatings combining a silica matrix and lignin. In fact, althought being the second most abundant biopolymer on Earth, is generally poorly used in highly technological applications, but its structure, rich in hydroxyl functions and aromatic rings, offers a very attractive hydrophobic potential for the generation of protective layers. In this work, the development of the coating is based on the combination of lignin and the TEOS by the "Evaporation Induced Self-Assembly (EISA)" technique, which allows the self -organized association of the organic and inorganic phases that, can be applied on the substrate. In order to determine the best solvent to be used for the process and how to optimize the inorganic matrix/lignin association, an extensive study related to lignin's characteristics was also carried out before its implementation. The scanning electron microscopy (SEM) study of the optimized hybrid layer before application on the substrate demonstrated the creation of a bilayer structure, with a silica network covered by spherical microparticles of lignin, what was further corroborated by XPS analysis, with the presence of signals associated with inorganic and organic networks. The coating phase was done by the use of Dip-Coating, technique that allowed the observation of the effects of the relative humidity and withdrawn speed on the surface structuration. The initial coatings characterizations on the substrate shows an inhomogeneous covering effect with a less well identified composite microscopic structure, which most certainly indicates a sol-gel/substrate interaction mode influencing the hybrid self-organization.

Biography

Gabriel Cardoso Gonçalves, current PhD in Physico-Chemistry of Materials, has a background as Materials Engineer and a Master's degree in Chemistry and Physical Chemistry of Materials. The current thesis is a collaboration between the University of Pau and Pays de l'Adour and the Federal University of Rio de Janeiro, under the supervision of Dr. Jean-Charles Dupin and Dr. Fatima Charrier-El Bouhtoury, with the collaboration of the Dr. Renata Simão. His research is related to the valorization of lignocellulosic biomass through the isolation of natural polyphenolic compounds. These compounds are later used as an eco-friendly source for the elaboration of new bio-based coating. Actually, he counts with 1 publication in international scientific journal, and he has participated in 1 national and international conferences.

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Natural fiber-reinforced geopolymers exposed to accelerated aging tests

Abstract

Geopolymers are ceramic brittle materials prepared from the reaction between an alkali solution with an aluminosilicate precursor, reaching its maximum strength up to 14 days, depending on the curing regime used. This class of advanced ceramics has been increasingly used for civil engineering applications, due to its pro-environmental aspects and enhanced durability. The incorporation of natural fibers appears as a green-friendly solution in reducing the CO2release that has been consistently involved in the manufacture of construction materials, in addition to providing excellent mechanical and ductile capabilities. However, its long-term durability must be assessed to provide enough reliability on the use of this type of technology as reinforcement layers and thin structures. For this reason, this study aims at the mechanical characterization of jute and sisal fiber-reinforced geopolymers, made of metakaolin, a sodium-based solution, and fine river sand. Thus, 4-point bending and tensile tests were performed with the composites reinforced with 10% of natural textile content, while direct tensile and pull-out tests were performed with the single fibers, after 14 days of regular curing. For the durability investigations, 5, 10, and 15 wetting and drying cycles were used and mechanically tested. Additionally, XRD, TG, and SEM techniques were used as chemical and morphological characterizations. In general, sisal-fiber reinforced composites presented enhanced mechanical properties, with strain-hardening and multiple cracking behavior, reaching up to 12 MPa in tensile, compared to 6 MPa found for jute. Also, the durability investigations demonstrated no significant ultimate strength losses up to 15 cycles, only the crack formation processes suffered modifications due to fibers stiffening.

Keywords: geopolymer, natural fiber, durability

Biography

I am currently a PhD student at PUC-Rio (Brazil), working on the development of geopolymer composites reinforced with natural and synthetic fibersfor extreme conditions, i.e., exposed to temperature, degrading environments, and impact. My research is conducted under the supervision of Prof. Flávio de Andrade Silva, an expert on the use of natural fiber reinforcements in cementitious binders. I've spent three months of my PhD working with Prof. Waltraud Kriven at Illinois (UIUC, USA), an expert on the geopolymer field, and also 6 months with Prof. Viktor Mechtcherine at Dresden (TU Dresden, Germany), an leading researcher on SHCC materials. So far I've published in cooperation with the leading professors mentioned above 11 international papers, with three more under revision, and 7 conference papers.

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SYNTHESIS OF MULTIFUNCTIONAL PHENOLIC COMPOSITES WITH THE VALORIZATION OF FORESTRY RESIDUES

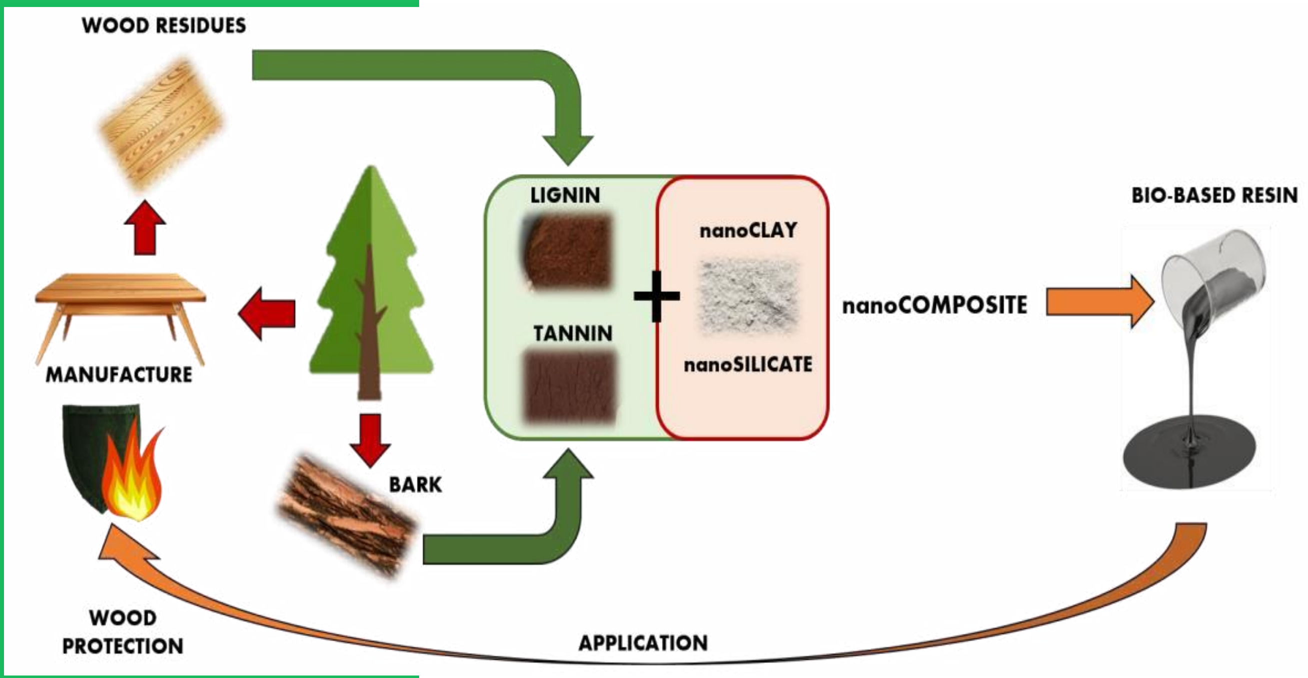
Abstract

In the field of materials, the current tendency is oriented towards the exploitation of raw materials coming from renewable sources. This point is of relevant interest due to its beneficial environmental, social and economic aspects. Within the different options available, the employment of biomass and especially lignocellulosic biomass is growing importance. Most commonly, the valorization of this type of biomass is carried out through the isolation of the single components. In this regard, a great deal of attention has been attracted lately owing to their phenolic compounds such as lignin and tannins. They are natural polyphenolic polymers and oligomers with a variety of potential applications in different domains. Thus, both of them have already been studied and tested as efficient matrix for the synthesis of bio-based materials. Nevertheless, it is possible that for some applications, certain properties such as mechanical strength or thermal resistance need to be improved. The combination of these natural phenolic compounds with other inorganic elements e.g. natural clays or silicates would therefore be a good solution to this issue. In fact, it has been reported in the literature the synergistic effect between organic and inorganic components in this kind of hybrid nanocomposites. In this work, the formulation of nanocomposites made of a phenolic organic matrix and inorganic nanoparticles was carried out. The polymer matrix was based on lignin and tannins, which were obtained from forestry biomass (*Pinus pinaster* wood residues and *Acacia mearnsii* bark respectively). As inorganic phase, organically modified montmorillonite (nanoclay) and polyhedral oligomeric silsesquioxane (nanosilicate) were selected. Considering the analyses implemented, it was observed the formation of polymeric chains composed of lignin and tannins moieties. Moreover, the introduction of inorganic nanoparticles within the organic polymeric chains was achieved. Concerning the performance of the nanocomposite, it was proved that the introduction of inorganic nanoparticles improved its thermal resistance. Besides, since the application intended was the elaboration of bio-based resins for the protection of wood against fire and a prominent part of the raw materials were obtained from forestry residues, this work would be related to the concept of circular bioeconomy.

Keywords: biomass valorization, nanocomposite, wood

Biography

Pedro Luis de Hoyos Martinez has a background as a Chemical Engineer, with a master and a PhD in Renewable Materials Engineering (2019). He developed his thesis in collaboration between the University of the Basque Country UPV/EHU and the University of Pau and Pays de l'Adour under the supervision of Dr. Jalel Labidi and Dr. Fatima Charrier-El Bouhtoury. His research is related to the valorization of lignocellulosic biomass through the isolation of natural polyphenolic compounds. These compounds are later used as a renewable source for the elaboration of new bio-based materials. As a result of this work, he counts with 12 publications in international scientific journals, majorly with a high impact factor (Q1) and he has participated in 12 national and international conferences.


WOOD RESIDUES
LIGNIN
nanoCLAY
TANNIN
nanoSILICATE
nanoCOMPOSITE
BIO-BASED RESIN
MANUFACTURE
BARK
WOOD
PROTECTION
APPLICATION

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Development and demonstrators of durable biobased composites for a marine environment

Abstract

There is a growing demand for composites for applications in a marine environment due to the growing markets for fish and seaweed farming, energy harvesting, boats, etc. At present only petrol-based composites are used, so there is an urgent need for renewable materials to be developed. These materials need to meet the highest technical performance and withstand the long term harsh marine environment. SeaBioComp is aiming to address this challenge by developing biobased composites to replace traditional fibre-reinforced composites used in the marine industries. The bio-composites reduce the use of fossil-based resources and limit the emission of greenhouse gases and the ecotoxic impact of microplastics, while allowing recycling by using thermoplastic biopolymers. One possible route that is explored is the use of self-reinforced thermoplastic biocomposites. By using a bicomponent extrusion technique, filaments are developed containing a high melting thermoplastic biopolymer as core with a layer of low melting thermoplastic biopolymer around it as sheet. After winding these bicomponent filaments on a frame, composites are made using conventional compression moulding. By carefully selecting the parameters of the compression moulding process, the sheet melts, acting as matrix around the solid high melting cores creating unidirectional fibre-reinforced composites. As a second approach, flax fibre reinforced composites are investigated. The flax fibres are combined with pure biopolymer or self-reinforced biopolymer to form hybrid preforms(e.g. intermingling, co-weaving, nonwoven). The reinforcement/matrix ratio is adjusted to optimise the mechanical properties while maintaining a good processability. The optimal process conditions for compression moulding are investigated to achieve good mechanical properties and a good impregnation. Apart from compression moulding, monomer infusion and 3D printing areal so explored as potential methods to develop fibre reinforced biobased composites for marine applications. In various marine applications, it is important to find the right balance between durability and end-of-life behaviour. For this reason, mechanical tests are carried out to determine the performance of the developed biocomposites, seawater aging tests are used to determine the long-term properties and to analyse the formation of microplastics. The effects of leachates on marine species are investigated to gain insights in the ecotoxicological effects of biocomposites.

Keywords: Self-reinforced, Natural fibres, Marine environment

Biography

Elke Demeyer graduated as a Master of Science in Bioscience engineering in 2019. After gaining her first experience in the coating industry, she joined Centexbel in 2021. As member of the Plastic Characterisation, Processing & Recycling group, her research focusses on the development of self-reinforced and natural fibre-reinforced biobased thermoplastic composites.

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Impact of physical treatments on fibers individualization and mechanical properties of a flax/PLA non-woven composite

Abstract

Technical fibers are composed of elementary fibers and fibers bundles. The cohesion between elementary fibers is ensured by a middle lamella. In natural fiber reinforced composites, an important parameter to have good mechanical properties is the individualization of the fibers. It has been shown that the middle lamella is an area of weakness in composites due to lower mechanical properties of this interfacial region. An aspect ratio (Length/Diameter) of the fibers greater than 10 is considered as the minimum value for good transmission of strength during mechanical stress loading.

Pre-treatments on plant fibers are common to increase the individualization of the bundles. To induce this individualization of the fiber bundles, several types of pre-treatments exist. Chemical pre-treatments are very commonly used. For instance, alkaline pre- treatments of KOH or NaOH type are used to eliminate components of the fiber such as pectin and hemicelluloses. But the use of chemicals on natural fibers question about their eco-friendly aspect. That is why some physical pre-treatments are also used to increase the individualization of the fibers bundles. Microwaves partially degrade the polymers rich in water molecules mainly present in the middle lamella.

In this work, two free of chemicals pre-treatments, ultrasound and gamma irradiation were applied to flax tows in order to increase the number of elementary fibers. First, the impact of the pretreatments on the diameter of the tows was monitored using a dynamic morphological analyser. For each pre-treatment, a 20% increase in the number of elementary fibers was observed. Then, biochemical composition was investigated; exhibiting a partial elimination of sugars relating to pectin and hemicelluloses. The hygroscopic behaviour made by dynamic vapour sorption (DVS) showed a decrease of the sorption-desorption water hysteresis for both pre-treatments. Non-woven composites were produced from treated tows with a bio-based and degradable matrix, poly-(lactid) (PLA). Moderate differences between the different composites was demonstrated; however, for the ultrasound pre-treatment, a significant increase of the stress at break was observed. Finally, life cycle analysis of the pre-treatments were carried out in order to quantitatively compare their impacts and gains in use for a composite application.

Keywords: Flax tows – Physical pre-treatment – Individualization

Biography

I'm graduated from an engineering school in materials science. My first experience with natural fibers was during an internship which had for subject the improvement of the interface of flax/PLA composite by nano-reinforcement which I carried out at the University of Sherbrooke in Canada Then I had the opportunity to do a thesis on flax fiber as part of the FLOWER project. The subject of my thesis concerns the use of unit physical pre-treatments for a flax material tailored to a composite application. And more precisely it relates to the individualization of fibers and to see the co-effects provided by the pre-treatments: biochemical composition, mechanical properties, hygroscopic behaviour.

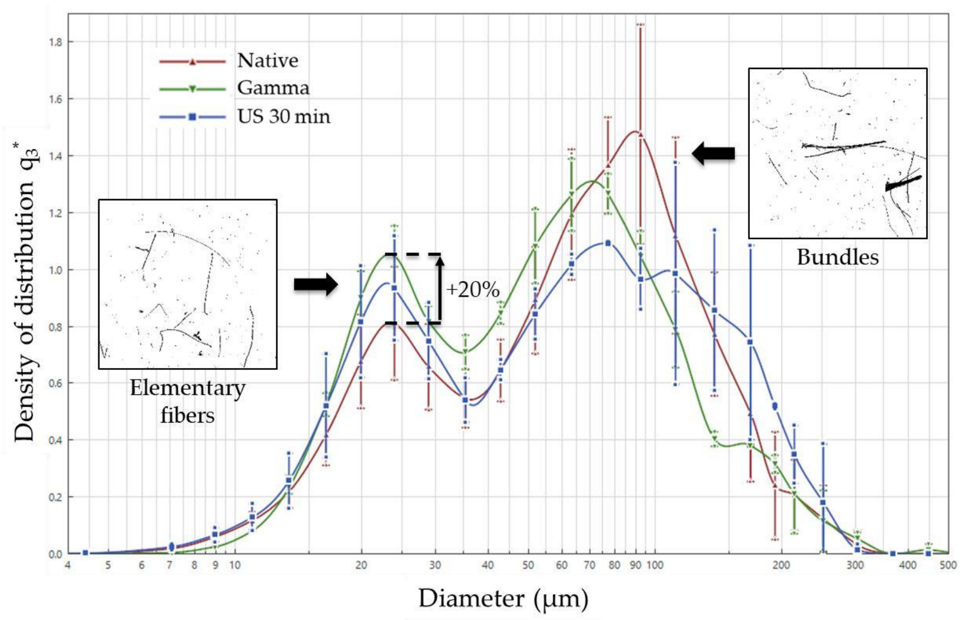

Figure.1 Evolution of density of diameter between native tows and treated tows

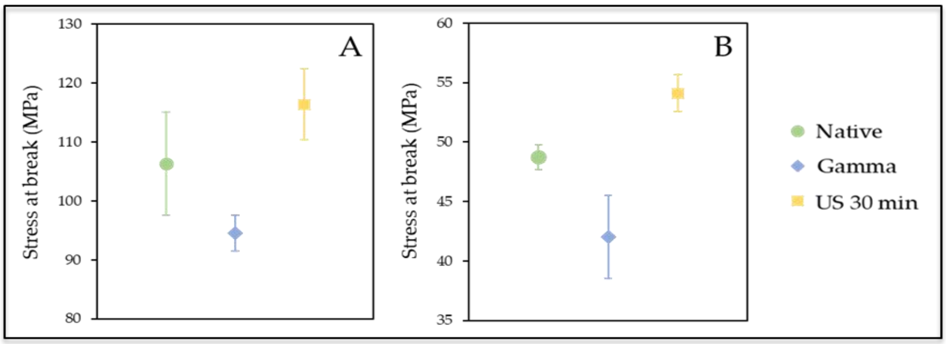

Figure.2 Stress at break in tensile tests on non-woven composite:

A. Machine direction B. Cross direction

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Biography

Giada Giuffrida was born in Catania (Italy) on 01/03/1991. Building engineer, she graduates with honours at the Civil Engineering and Architecture Department of University of Catania with a thesis on the restoration of historical rammed earth architecture in the city of Granada (Andalusia), based on studies undertaken during her internship at the LAAC (in 2015), a research group of CSIC - Consejo Superior de Investigaciones Científicas in Spain.

Between 2017 and 2018, she participates in several international workshops and masterclasses on the use of natural materials in contemporary construction; among them, the LearnBion workshops held in Montemor-oNovo (Portugal) and Casaprota (Italy) in 2017, the BASEHabitat Summer School held in Altmunster (Austria) and the Arquitectura tradicional e Identidad local Workshop organised by Made in Tierra in Paredes de Nava (Spain), both in 2018.

The same year she is awarded with an industrial doctorate scholarship at the University of Catania, with a project concerning the implementation of innovative building systems in unfired earth, which leads her to collaborate with the Guglielmino Soc. Coop. and the Centro Tierra-INTE of the Pontificia Universidad Católica del Perú in Lima. Her doctoral research is focused on the performances improvement of unfired earth materials, the design of energy-efficient, earthquake-resistant unfired earth building systems and the optimisation of their construction and production processes.

Giada Giuffrida is co-authors of several contributions accepted in national and international conferences and published in peer-reviewed journals, covering topics like the use of natural building materials for new constructions and energy-retrofit interventions, assessment of physical, mechanical and thermal properties of raw earth-based materials, natural based constructive technologies, sustainability in construction and production, thermal and energy simulation of buildings.

Use of Arundo Donax (giant cane) by-products in high-performance building components.

Abstract

The increasing high-performance energy requirements and the need to ensure adequate environmental sustainability of the entire production and construction chains are at the core of the international debate on the future of construction sector. To answer these demands, new investigations on alternative building products, using natural materials and/or waste by-products, and on manufacturing processes are being developed in line with circular economy school of thoughts.

Materials such as hemp or straw have been extensively tested at international level, but the possibility of using common cane has not been sufficiently investigated despite being a common infesting plant, abundantly available in various European territories and thus affordable. In this contribution we explore the possibility of producing building components reinforced with waste products from Arundo Donax (giant cane).

Our research group carried out a study to assess the performances of lime-canes mixtures for bricks, blocks, panels or loose insulations. After describing the properties of the raw materials employed in the investigation (Arundo donax by-products, lime, etc.) a methodology for the manufacturing of these innovative building components, and the assessment of their physical, mechanical and thermal properties are proposed. Between the tested specimens, thermal conductivity below 0.20 W/m K and compressive and flexural strength up to 1.50 MPa and 0.87 MPa were achieved, satisfying building codes requirements for non-bearing walls.

These results are promising for the manufacturing of innovative natural-based building components using byproducts from other production chains, resulting in a containment of environmental impacts and reduction of construction waste. The building components developed in the study answer to the increasing demand of products which can be both used in new environmentally sustainable construction and for energy retrofitting of existing building stock.

This contribution covers both the manufacturing, design and testing topics of the ESBBC summer school, by proposing a novel design approach for the use of plant fibres in advanced composites for construction sector.

Keywords: Arundo donax, lime-cane mixtures, performances assessment

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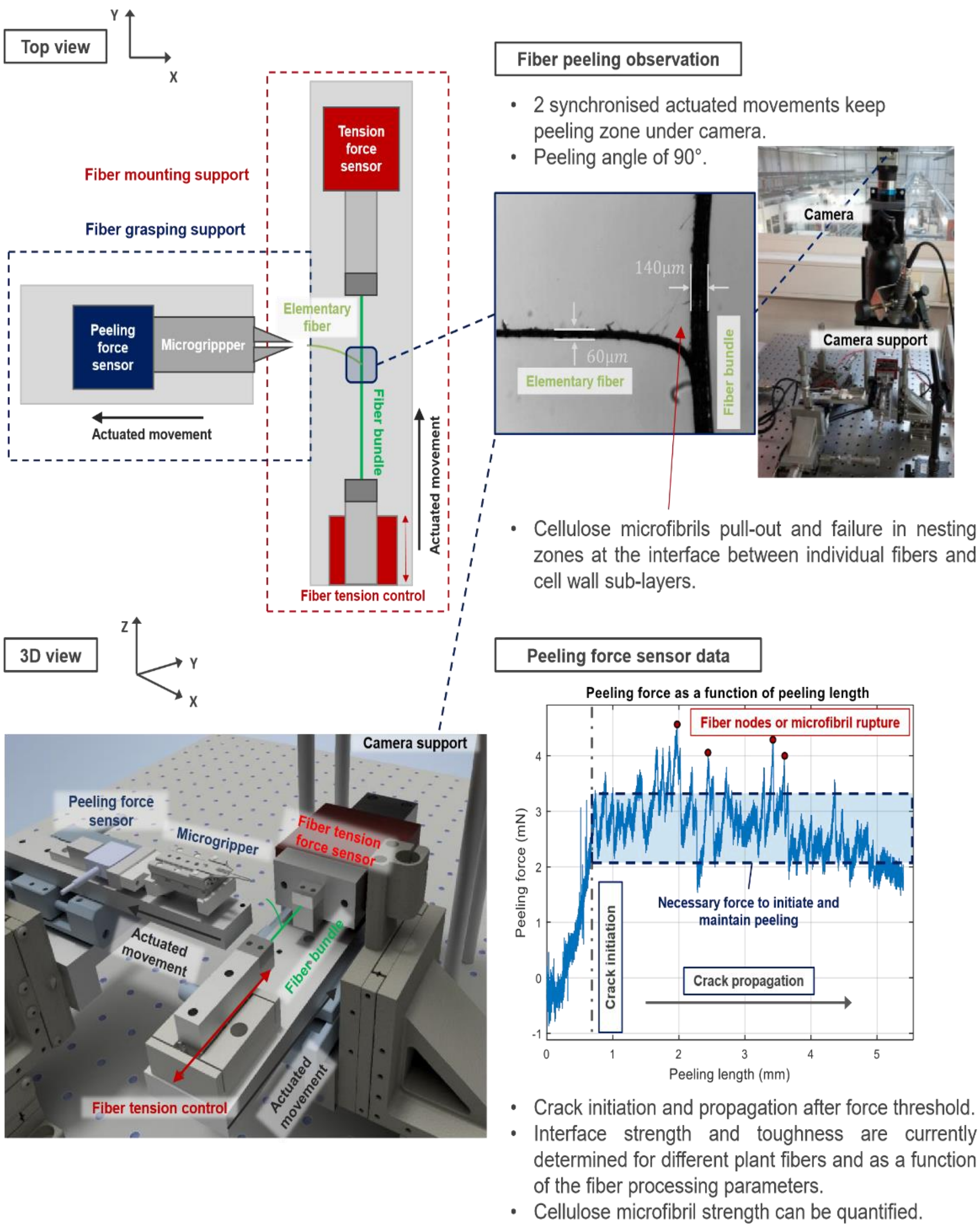
Investigation of the mechanics of interface between individual plant fibers using micro-mechatronics

Fiber peeling micro-mechatronical setup:



Keywords: Interface mechanics, inter-fiber adhesion, fiber peeling, micro-mechatronics.

Biography

Jason GOVILAS has graduated from the University of Franche-Comté with a Master's Degree in mechanical engineering. He is currently on the second year of his PHD, at the FEMTO-ST institute in Besançon, on the development of micro-mechatronical setups for fiber characterization, with a main focus on plant fibers. This brings him to work for the bio-composite and micro-nanorobotic teams of the institute while also collaborating with the department of the French agronomical institute in Nantes. He is part of the NETFIB project (Valorisation of nettle fiber grown on marginal lands in an agro-forestry system), tasked with identifying the transverse mechanical properties of single nettle fibers.

Marie Grégoire, Emmanuel De Luycker, Pierre Ouagne

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Hemp fibre mechanical and morphological properties from different carded rovings for composite applications

Abstract

Long used in the textile industry and for the manufacture of ropes and sails, hemp cultivation gradually declined throughout the 19th century until it was banned in the mid-20th century. Today, most bio-sourced technical textiles are made from textile flax fibres. Despite the growing demand, traditional flax growing areas are limited and an alternative to this material had to be found. Hemp is well adapted to European growing conditions and its components (fibres, seeds and shives) can be used in many areas. However, hemp fibres are currently extracted using aggressive techniques such as hammer mills, which only allow them to be used in the paper industry and as short-fibre reinforcements in composite materials. In order to use these hemp fibres in structural composites, it is therefore necessary to extract them using devices that maintain the highest possible mechanical and morphological properties.

Two main extraction routes were tested in this research work. The first, called scutching/hackling, is used if the input material is oriented. However, hemp is, in most regions, harvested in the traditional way using combine harvesters, which does not allow aligned material to be obtained. In this case, a so-called "all-fibre" extraction device is used, which corresponds to the traditional hemp route. Different devices exist. In our case, it is composed of two distinct modules: a succession of breaking rollers and a breaking card.

The analysis of the mechanical and morphological properties of the fibres after different stages of the two extraction processes as well as after drawing confirmed the potential of these two extraction processes for obtaining hemp fibres suitable for use in structural composite materials.

Keywords: Hemp fibres, fibre extraction, drawing, mechanical properties, morphological properties

Biography

Dr Marie GREGOIRE-BUESA is currently temporary assistant professor in the Laboratoire Génie de Production (LGP) of the Ecole Nationale d'Ingénieurs de Tarbes (ENIT). After a mechanical engineering Master obtained at ENIT, she joined the bio-composites and textiles group headed by Prof. Pierre OUAGNE in 2017 for her thesis, within the SSUCHY project, a European project which objective is to develop 100% bio-sourced structural composite materials. She successfully defended her thesis "Extraction of hemp fibres for structural composites" in January 2021. Her research work ranges from mechanical extraction of plant fibres to their morphological and mechanical characterization.

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Biography

The author is a second year PhD student at IMT Lille Douai, France. She has a masters degree in applied mechanics from Ecole Centrale de Nantes, France. She looks for a job in the future in composite materials industry.

Laser transmission welding of short flax fiber reinforced thermoplastic composites

Abstract

Positioning in the theme list = Bio-based materials design, perception and emotional aspects)

Laser transmission welding (LTW) is a process used for joining thermoplastic plastics and composites. Project ATHENS is a part of INTERREG FWVL program aiming to study the assembly techniques of bio-sourced composite materials. As a partner of ATHENS, IMT Lille Douai is working on the analysis and optimization of LTW of short flax fiber reinforced thermoplastic composites. In this work, we present the numerical analysis of LTW process to obtain the temperature field at the welding interface.

Of the two materials that are to be welded, one should be transparent to laser wavelength and the other absorbent. During welding, the two materials are clamped together, and a laser beam is projected towards their interface. The laser passes through the transparent part before reaching the material interface, where the laser energy is absorbed by the absorbent part and the two materials are heated and melted locally. A welded joint is formed at solidification. This process is challenging with the existence of opaque phases, viz. short flax fibers, in the transparent part, because they scatter the laser rays, causing a loss of energy reaching the weld interface.

The material properties (in particular, thermal and optical properties), laser characteristics and welding time influence the interfacial adhesion strength established by the laser welding process. To predict the interfacial bonding strength, the temperature field at the interface is calculated numerically, because there is no means to measure the temperature at the interface.

3D structures have been generated as numerical RVEs (Representative Volume Elements) with an aim to consider the real morphology of a composite material with short fibers using fiber volume fraction, fiber length distribution and fiber orientation distribution information extracted from µCT observations. The fiber orientation state is represented by orientation distribution function converted from fiber orientation tensors.

An algorithm for ray tracing implemented in MATLAB code is applied on the structure to follow the path of diffused laser rays in the transparent part. A laser intensity distribution is obtained from the simulation and is imported into COMSOL for heat transfer simulations. The laser source term obtained from ray tracing simulation is defined as the boundary condition in the heat conduction simulation. Finally, the temperature distribution at the interface obtained from the heat transfer simulation will be used for further studies to predict the weld strength.

Keywords: Laser transmission welding; natural fiber reinforced thermoplastic composites; fiber orientation tensors.

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Interfacial Toughening of Flax Fibre Reinforced Composites for Better Impact Resistance

Abstract

The application of natural flax fibre composites is growing in the automotive and marine sectors due to their good stiffness and damping properties. Specifically, in-situ polymerisation of flax fibre reinforced composites with epoxy or poly (methyl-methacrylate) (PMMA) enable room temperature manufacturing of large and structural solid parts. In-situ polymerisations of flax/epoxy and flax/PMMA composites offer good fibre/matrix adhesion based on covalent and hydrogen bonding. However, the impact damage resistance of flax/epoxy and flax/PMMA composites is limited due to the brittle nature of these polymers and flax fibres and strong fibre/matrix adhesion. Here, biobased thermoplastic cellulose acetate (CA) and tough PMMA copolymer are deployed as a fibre treatment to respectively alter the damage development of flax/epoxy and flax/PMMA composites subjected to low-velocity impact.

The perforation energy of unmodified cross-ply flax/epoxy composites significantly increased by 42% with CA-treated flax fibres. Also, CA-surface modification enhanced the Charpy impact strength of unmodified UD flax/epoxy composites by 38%. The UD CA-flax/epoxy had similar quasi-static tensile strength and elastic modulus as those of unmodified flax/epoxy. CAmodification modestly decreased the transverse tensile strength and in-plane tensile shear strength (IPSS) of the composites. However, it altered the brittle nature of flax/epoxy laminates in quasi-static tests into ductile failure with clearly increased fibre-matrix debonding.

Although flax/PMMA composites had similar perforation energy as flax/epoxy, the quasi-static tensile performance of flax/epoxy was better than flax/PMMA, mainly transverse strength (53%) and IPSS (28%) values. However, surface modification of flax fibres with tough PMMA copolymer improved the perforation energy (14%) and the transverse tensile strength (20%) of unmodified flax/PMMA composites.

The findings showed that interfacial toughness plays a critical role in designing impact resistance flax/epoxy and flax/PMMA composites. Our results showed that it is possible to control how the impact damage manifests itself in flax/epoxy composites from ply splitting and extensive fibre failure to local fibre/matrix debonding and fibre failure at rear-face ply. This research can promote the further application of biocomposites in the transportation sectors.

Keywords: Natural fibres; Surface treatments; Impact behaviour

Biography

Farzin Javanshour is a PhD student in materials science and environmental engineering at Tampere University, Finland. He has a background in solid mechanics (B.Sc.) and materials science (M.Sc.). In Aug. 2018, he joined the FibreNet (H2020-MSCA-ITN) project to study fibre/matrix adhesion in flax fibre reinforced composites. His PhD topic is to develop surface modification strategies to improve damage tolerance and longevity of flax/epoxy and flax/PMMA composites under low-velocity impact and fatigue loading conditions. His research interests are damage tolerance, toughening, biobased and bioinspired polymeric composites.
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Biography

In 2016 I graduated from a HND in measurement in physics from the University of Caen. Back in these days I had no idea of what I wanted to do but I was still curious to learn more about chemistry. So I did a year of bachelor in chemistry at the University of Caen and by the end of the summer of 2017 I started my first year of engineering school at ISPA in Alençon (Normandy). This school is specialized in polymers and composite materials. During the diploma, I was an apprentice engineer working half of the time in a company named Dedienne Multiplasturgy. Three years later I graduated from this engineering school and I decided to continue my studies in the academic field as a PhD student. I am currently working on an environmental research project that corresponds to my beliefs and I am glad to be part of a team that tries to find solutions to solve one of the many environmental issues of this century.

Influence of natural fibres on curing kinetic of biobased resins

Abstract

Over the past few decades natural fibres have been the subject of many research projects in order to provide sustainable solutions to create more environmentally friendly composite materials. While the mecanichal and the hygroscopical aspects of natural fibres are in the heart of debates, it is on the chemical interactions between natural fibres and expoxy biobased resin that this study will focus on. Experimental observation reveals that the presence of natural fibres in an epoxy resin delays its crosslinking process with an average deviation of Tg of 10°C between composites reinforced with natural or synthetic fibres. This study, which aim is to understand the chemical mechanisms that affect the cross-linking kinetics of a partially biobased thermoset resin, is based on a multi-scale approach.

In one hand, chemical interactions, between epoxy resin and organic compounds, are studied at the macroscopic level, glass transition temperature, exothermic peak due to cross-linking.

In the other hand, at the atomic scale, by applying the principle of Newton's Second Law of Motion it is possible to predict the displacements of a group of particles allowing us to numerically simulate chemical reactions such as the cross-linking of an epoxy resin. The effects of additional elements such as water, chemical groups present on the fibre surface can be understood. Some first results showed that water has a catalyst effect on the crosslinking but the recently formed bonds looks particularly weak. With deeper analysis, we conclude that the hydroxyl groups are responsible of this phenomenon. By extension, it is fair to ask the question : Are the hydroxyl groups contained in the structure of natural fibres responsible of the cross-linking issue?

Keywords: curing kinetics ; cross-linking; molecular dynamics

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Biography

Ali Kandemir is a material scientist & engineer, and a PhD candidate in Department of Aerospace Engineering at University of Bristol. He used to perform research into ultra-thin, two-dimensional nanomaterials. Now, he is interested in combining novel composite manufacturing methods with sustainable constituents to produce environmentally friendly advanced composites. His research interests are; discontinuous fibre reinforced polymer composites, sustainable composites, advanced composites, natural fibres, and repairable/reusable matrices.

Natural Fibres as a Sustainable Reinforcement Constituent in Aligned Discontinuous Polymer Composites produced by the HiPerDiF Method

Abstract

There is an expanding societal concern about the environment relating to sustainability in many engineering fields, including fibre reinforced polymer matrix composites. Due to their non-environmentally friendly constituents, i.e. thermosets and synthetic fibres, this sector is committed to researching sustainable solutions. Two different approaches can be considered for possible solutions, and the first approach is reducing the environmental impact of constituent materials by using sustainable raw materials, such as natural fibres and bio-based matrices. The second approach is reducing landfill waste by considering "repair, reuse or recycle" for composites. Because the composite industry uses mostly thermoset matrices, which are irreversible when cured, it is difficult to apply the second approach. However, thermoplastic matrices or Covalent Adaptable Network polymers can overcome this and make it easier to apply the second approach. Furthermore, changing the fibre reinforcement geometry from continuous to discontinuous promotes and facilitates the concept of repair and reuse, which are quite difficult to achieve with continuous fibre reinforced composites. This is because after the possible repair or reuse process, factors such as manufacturing defects, flaws and bottlenecks will be altered and all assumptions will become invalid; alternatively, those of discontinuous fibre composites remain relatively the same. In this study, a number of plant based natural fibres - curaua, flax, and jute fibres - are used to reinforce epoxy, poly(lactic acid) (PLA), and polypropylene (PP) matrices to form aligned discontinuous natural fibre reinforced composites (ADNFRC). The novel HiPerDiF (high performance discontinuous fibre) method is used to produce high performance ADNFRC. The tensile mechanical, fracture, and physical (density, porosity, water absorption, and fibre volume fraction) properties of these composites are showed. In terms of stiffness, epoxy and PP ADNFRC exhibit similar properties, but epoxy ADNFRC shows increased strength compared to PP ADNFRC. It was found that PLA ADNFRC had the poorest mechanical performance of the composites tested. Moreover, flax fibres with desirable fibre lengths (greater than the critical length) are considered to be the best reinforcement constituent for future sustainable ADNFRC studies in terms of mechanical performance and current availability on the market, particularly for the UK and EU.

Keywords: sustainable composites, mechanical properties, aligned discontinuous fibre composites

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Experimental simulation of the outdoor humidity in Western Europe and its effect on the properties of flax fibre reinforced composites

Abstract

All materials, and hence also composite materials, are to some extent influenced by environmental factors like moisture, temperature, UV radiation, and the presence of chemicals and micro-organisms. To guarantee continued performance of load bearing structures and avoid excessive safety factors in the design, the characteristics of the environment, and its effect on the material properties over time, should be known.

Based on the monthly humidity averages between 2010 – 2019 of weather stations across France, Germany, Switzerland and Belgium, the average humidity of the Western European outdoor climate is estimated at 85%RH in winter and 65%RH in summer. Since moisture ingress in composite materials is generally slow, it is assumed that the moisture content in the composite, exposed to the Western European outdoor climate, will largely follow these average humidity levels.

In this study, Flax fibre reinforced composites were subjected to a relative humidity of 65 and 85%, in a cyclic manner, at 40°C. Therefore, one ageing cycle in the lab could be linked with one year in service.

Results showed a reduction of composite stiffness by 25% after saturation at the average winter humidity of 85%. This reduction was linked to increased fibre plasticity, however, the absolute decrease is lower than previously reported in literature (Berges et al, 2016; Gager et al, 2019; Scida et al, 2013). In addition, a reduction in composite strength and failure strain was found after prolonged exposure to variable moisture conditions which can be linked with the development of microscopic damage (Koolen et al, 2020).

During the summer school, conclusions will be presented for the first 8 months of the ageing study.

Keywords: Flax fibre composites; Humidity; Durability

Biography

Ing. Gilles KOOLEN obtained a Master in Chemical Engineering Technology from KU Leuven, Belgium in 2017. He was awarded funding by the H2020 Ssuchy project and is currently working as a PhD researcher at the KU Leuven Department of Materials Engineering. His research mainly focuses on reducing the moisture sensitivity of natural fibre composites. Beside his position in academia, he is a member of European Scientific Committee of the European Confederation of Flax and Hemp (CELC).

References

Berges, M., Léger, R., Placet, V., Person, V., Corn, S., Gabrion, X., Rousseau, J., Ramasso, E., Ienny, P. & Fontaine, S. (2016) Influence of moisture uptake on the static, cyclic and dynamic behaviour of unidirectional flax fibre-reinforced epoxy laminates. Composites Part A: Applied Science and Manufacturing, 88, 165-177.

Gager, V., Le Duigou, A., Bourmaud, A., Pierre, F., Behlouli, K. & Baley, C. (2019) Understanding the effect of moisture variation on the hygromechanical properties of porosity-controlled nonwoven biocomposites. Polymer Testing, 78, 105944.

Koolen, G., Soete, J. & van Vuure, A. W. (2020) Interface modification and the influence on damage development of flax fibre – Epoxy composites when subjected to hygroscopic cycling. Materials Today: Proceedings.

Scida, D., Assarar, M., Poilâne, C. & Ayad, R. (2013) Influence of hygrothermal ageing on the damage mechanisms of flax-fibre reinforced epoxy composite. Composites Part B: Engineering, 48, 51-58.

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Biography

Since late 2019, Martin Lefebvre is a PhD student at the Strasbourg University (France) in the ICube -

Engineering science, computer science and imaging laboratory. He was graduated from INSA

Strasbourg engineering school in 2018 in mechanical engineering. During his end of Master's thesis at INSA, he worked on the design and fabrication of a hydrogen long range drone (Interreg ELCOD project). In parallel, his composites materials teacher was Pr. Nadia Bahlouli (MMB Team – Strasbourg University). She taught the high potential of natural fibers during his Master. At that point, started his taste for innovative and eco-friendly engineering solutions and the idea to use bio-based composites for the drone.

Then, started the PhD project supervised by Pr. Nadia Bahlouli. The first motivation was to change the structure of the drone to bio-based composites. However, after one year of PhD, the drone moved to background and the studies were oriented to more global problematics: Characterization of flax fibers and flax fibers composites for general applications (automotive, nautical, defense, etc.).

As an engineer, the investigation of bio-based fibers and composites is a wonderful opportunity to work in favor of the link between academic research and industrial applications. Incredible engineering solutions are coming from nature and it is highly motiving to investigate them.

Elementary flax fibers tensile tests: from quasi-static behaviour to strain-rate dependent model

Abstract

The starting point of the study is about the design the world first long range bio-based drone structure and to investigate the replacement of petro-based composites. However, there are limitations before employing a total structure made of flax fiber reinforced composite. Indeed, if flax fibers are interesting in term of strength, stiffness and density, literature shows a lack of standard and an absence of data concerning mechanical properties with the strain-rate and temperature sensitivities. In this study, tensile tests are performed on elementary flax fibers to obtain the mechanical properties depending on fiber characteristics and strain rate sensitivity.

Elastoplastic constitutive behavior is properly observed on the quasi-static tensile stress-strain curves (strain rate of 0.0017 s^{-1}). In scientific reviews, the increase of rigidity is interpreted has a reorientation of the initial microfibril angle (MFA) of cellulose chains during the tensile test. The second significant observation is the decreasing of mechanical properties when the fiber diameter increases. This result can be partly explained by the increasing of flaws and porosity in the elementary fiber when the diameter increases. Those experiments results are coupled with SEM observations on fibers sections and fracture surfaces.

After quasi-static tensile tests, the following step is to investigate the behavior of the elementary flax fiber at different strain-rates. The objective is to identify a predicted strain-rate dependent model. Three strain-rates are selected to perform the tests: 0.0017 s^{-1}, 0.017 s^{-1} and 0.17 s^{-1}. Tensile tests show a decreasing of tensile strength and tensile modulus when strain-rate is increasing. However, the strain at failure looks constant. Microstructure of flax fibers must have a high viscous behavior which can explain those results. During high speed tensile test, rearrangement of cellulose chains doesn't seem to have time to occur and the lignin seems to carry out a crucial role at high strain-rate.
An accurate modelling will describe the complex structure and behavior of the elementary fiber. Taking the morphological dependency and the strain-rate dependency into account. The ultimate objective will be to investigate homogenization from microscopic scale to the scale of the composite.

Keywords: Flax fibers, Tensile properties, Strain-rate sensitivity

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Biography

Maria Morissa Lu is a PhD student at the Department of Materials Engineering, KU Leuven, Belgium. Her research topic is on 'Improving the moisture durability of flax fibre composites by using non-dry fibre' which is funded by the EU-H2020 BBI project "SSUCHY" and the University of the Philippines. She is also an assistant professor in the Department of Engineering Science in The University of the Philippines where she teaches Engineering thermodynamics, Mathematical methods in engineering and Manual and computer-aided design drafting. Aside from teaching she was also involved in research on developing new materials. She worked as project leader in a research on "Evaluation of Nanosilica Powder from Rice Hull Ash Used as Silicon Fertilizer for Tomato (Lycopersicon esculentum)" under the University of the Philippines Nanotechnology Program "Development of Nanosensors and Nanostructured Materials for the Enhancement of Food and Agricultural Productivity and for Environmental Remediation".

Publications:

M.M. Lu and A.W. Van Vuure. Effects of water immersion ageing on composites made of non-dry flax fibres. Materials Today Proceedings, 31: S206–S208, 2020.
M.M. Lu and A.W. Van Vuure. Improving moisture durability of flax fibre composites by using non-dry fibres. Composites Part A: Applied Science and Manufacturing, 123: 301–309, 2019.

Reliability of water immersion test in predicting the properties of flax composites exposed to outdoor conditions.

Abstract

Natural ageing tests can directly reflect the changes in the properties of natural fibre composites (NFC) in a service environment. However, most research on the durability of NFC focuses on accelerated ageing due to their convenience and time-saving. This study determines the reliability of the water immersion test (IMM) in predicting the flexural properties of both flax/polyester and flax/epoxy composites exposed to outdoor conditions by comparing the results to the natural ageing test (NAT). In the study, the edges of all samples were uncoated. Fig. 1 shows the longitudinal mean strength of composites subjected to water immersion and natural ageing tests.

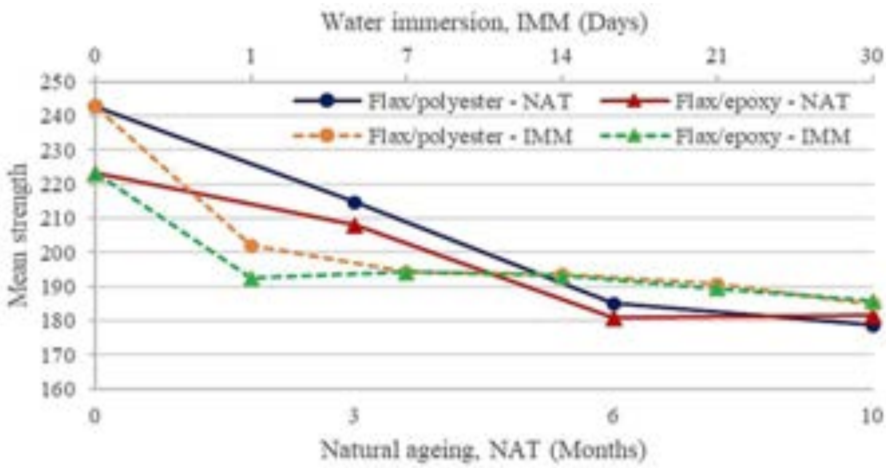

Figure 1. Mean strength of the composites in longitudinal fibre orientation subjected to water immersion (IMM) and natural ageing tests (NAT).

The reduction in mean strength of composites is already high after day 1 of immersion and the reduction becomes minimal between day 1 until saturation. The NAT test resulted in a significant decrease in the mean strength after six months of ageing and remained almost the same until ten months. After 30 days of the IMM test, the mean strength of flax/polyester and flax/epoxy composites decreased by 24% and 17%, respectively. The reductions are almost the same as for the NAT test samples after ten months. In general, the results of the study led to the conclusion that the water immersion test could be used as representative of the long-term durability of uncoated NFC in natural conditions. It is confirmed that the simplest water durability study, the water immersion test, is sufficient to simulate the natural exposure of uncoated composites.

Keywords: Flax composites, Water immersion, Natural ageing

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Biography

Currently, Ph.D student at the University of South Brittany since November 2018, I am one of the members of FLOWER project with the purpose of characterizing flax fibres for a future application as reinforcement in biocomposite materials for boat prototypes, panels and automotive.

After my studies in the "Edgardo Mannucci" art high school, in 2014 I obtained a bachelor's degree in conservation and restoration of the cultural heritage at the University of Camerino.

I took part in the ERASMUS program in 2016 in Paris at Monaris laboratory where I studied archaeological objects made from bones, ivory and antlers by vibrational spectroscopy and learned French at the same time. I obtained a master's degree in science for conservation and restoration of cultural heritage at the University of Parma in 2017 and after the obtention of my master diploma I successively completed an internship in a private water treatment laboratory (Feedwater ldt.) in Liverpool. In 2018 I applied for and obtained the Ph.D position at the University of South Brittany in materials engineering. My background in cultural heritage field allowed me to orienteering my thesis between engineering and art fields, creating, in parallel to the FLOWER project, a collaboration with the Louvre museum, the Art gallery of Ascoli Piceno, the University of Camerino and the CNR to study and characterize the ageing mechanisms and the state of conservation of cultural artefacts made from flax fibres.

I attended two international conferences, the InArt 2018 in Parma and the LMP2019 in Prague.

Flax between art and engineering: focus on factors that influence the mechanical properties of technical fibres

Abstract

Flax is one of the most ancient cellulosic materials used by men in both engineering and cultural heritage fields. However, the mechanical properties of flax fibres are unpredictable because they are dependent on environmental conditions during plant growth, extraction methods that can create defects along the fibre axis (kink-bands), the ultrastructure and chemical composition of fibre cell as well as their ageing mechanisms. For this research, we have chosen to couple cutting-edge techniques such as atomic force microscopy, second harmonic generation microscopy and deep UV fluorescence microscopy at Synchrotron SOLEIL.

Studying plant growing conditions in view of climate change, we observed that the mechanical properties of flax fibres did not change despite the plant was grown in a drought environment, causing chemical and morphological modifications at both plant and fibre levels. In particular, a high lignification and high disorder in cell matrix were noted in fibres from stressed plants.

In other fibres of good quality, cellulose microfibrils were identified and their angle calculated. However, their angle deviates in kink-bands creating cavities into the microfibril network and making these points sensitive to breakage.

The study of a PLA/flax composite degraded in compost demonstrated that bacteria and fungi preferentially start to degrade flax fibres from the lumen, propagate following the microfibril network and are delayed/inhibited by lignin especially present in S layers of the cells.

From the study of cultural objects (mortuary linen from Egypt of 4000 years ago and four paintings on canvas dated 1600-1700 century), we confirmed that kink-bands are the weakest points of fibre ultrastructure (fractured, they can be easy access for hydrolysis and microorganisms) and their morphology could depend on the fibre extraction methods used. Acid hydrolysis and microbiological attack are two of the main degradation mechanisms affecting ancient linen. In favourable environmental conditions, the crystalline cellulose and the microfibril angle of cellulose microfibrils in flax fibres are well preserved also after centuries; on the contrary, hemicellulose and cell matrix are subjected to modification during years. External materials applied on fibres surface can act as a barrier and change the natural ageing process of flax fibres.

Keywords: flax fibres, mechanical properties, degradation mechanisms

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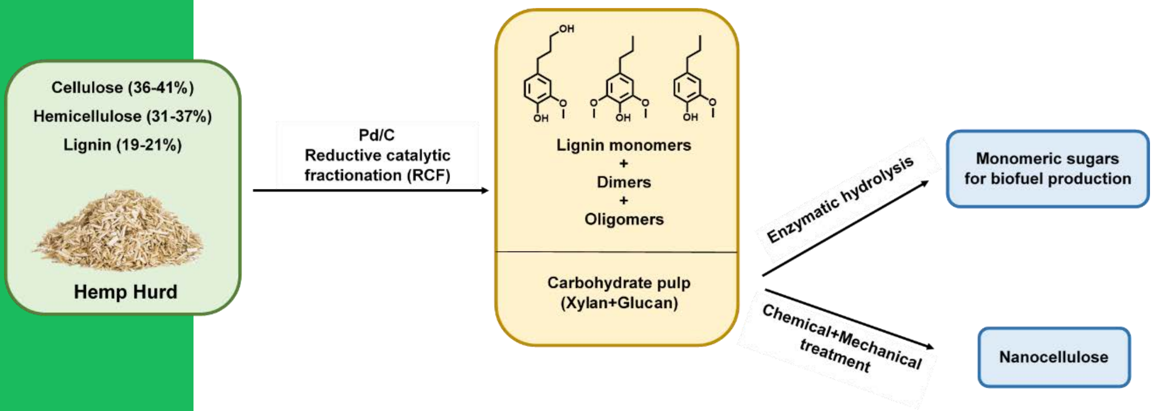
Reductive catalytic fractionation of hemp hurd (low-valued residues) from textile fiber production

Abstract

Valorization of hemp was conducted by reductive catalytic fractionation (RCF) of hemp hurd to produce aromatic monomers from lignin, fermentable sugars, and nanocellulose from carbohydrates. The yield of monophenolic compounds was optimized by varying the reaction time and the amount of formic acid. Chemical degradation methods such as acid hydrolysis (Klason method), thioacidolysis, and nitrobenzene oxidation were used to confirm the lignin structure and content. Monomer products were determined qualitatively by gas chromatography-mass spectrometry (GC-MS) and quantitatively by gas chromatographyflame ionization detector (GC-FID). Aromatic oligomers were estimated by gel permeation chromatography (GPC). We found an unexpected high yield of monophenolic compounds (38.3 wt%). This is higher than analogues woods having similar lignin content. Nanocellulose can be obtained after chemical and mechanical treatment from bleached-pulp. Moreover, enzymatic hydrolysis was conducted to convert cellulose to glucose, which can be further used in biofuel production.



Biography

Suthawan Muangmeesri obtained her Bachelor degree in Applied Chemistry (Material Science) at Department of Chemistry, Chulalongkorn University, Thailand. Her bachelor thesis conducted under the title "Synthesis of lignin model compounds, representing the β - β bond." Currently, she is a first PhD student in Organic Chemistry Department, Stockholm University Sweden. She has a strong interest in valorization of biomass, especially waste and low value biomass for a sustainable energy development. Her PhD studies focus mainly on valorization biomass especially catalytic fractionation of biomass (From biomass to sustainable building blocks).

Keywords: reductive catalytic fractionation, lignocellulosic biomass fractionation, ligninderived monomers, hemp hurd, nanocellulose

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Are biodegradable polymers suitable as matrix for biodegradable flax composites ?

Abstract

Composites have a variable environmental impact depending on the choice of reinforcement and matrix. Combining flax fibres and biodegradable thermoplastics may lead to composites with limited impacts and recycling or biodegradation as potential end-of-life scenarios [1].

Among the biodegradable matrices available, poly(lactide) (PLA), poly-(butylene-succinate) (PBS) and poly-(hydroxyl alkanoate) (PHA) was used in this thesis as they present significant stability and reliable mechanical properties. Poly-(propylene) (PP) is used as an industry benchmark.

Interfacial analysis between flax fibres and biopolymer was investigated at micro-scale level (micro-droplet debonding) as well as at macro-scale level (in-plane shear stress). The influence of interface explained the higher mechanical performance observed for biopolymer/flax unidirectional composites.

As non-woven preform are currently utilised to process low-cost thermoplastic composites at large scale, a second study focussed on non-woven flax/PLA to understand how the composite mesostructure influences its mechanical properties. Fibre volume fraction, porosity, fibre orientation as well as shives content were used to describe the mesostructure and to approximate the non-woven flax/PLA mechanical properties using laminate theory.

Another important aspect to consider is the durability and life-in-service time. Non-woven made of PLA, PHA, PBS, PP and flax where burried in a garden compost for 6 months and periodically assessed. The loss in mechanical strength of biodegradable composites after 6 months was comparable to the industry reference, flax/PP. Furthermore, two distinct degradation behaviours were observed: surface degradation and bulk degradation. The first one appears to be more predictable, whereas the second induces fibre/matrix decohesion leading to early, drastic loss of mechanical properties.

Regarding all these studies, it appears that biodegradable polymers could be an alternative to PP for thermoplastic flax composites. However, further studies related to the ageing behaviour under thermal and humidity cycling needs examination before using these biodegradable composites at industrial scale.

This talk could be a part of either of these topics:

- Manufacturing, design and durability
- End of Life management, sustainability assessment, circular bioeconomy

Biography

My name is Delphin Pantaloni, I am currently a PhD student at the University of South Britany, in Lorient. This thesis focusses on the possibility to use biodegrable polymers for matrix in flax composites.

How I arrived here: I was in preparatory school at Nantes for two years (2013 -- 2015). After competitive examination, I succeeded to join Phelma, an engineering school with a specialization on materials science. Over two years, I studied this science, mainly focusing on metals and semiconductors. Besides, I also learnt to snowboard as Grenoble is the perfect place to go skiing frequently. During this time, I was lucky to have the opportunity to go to Peru and Australia for my internships. Finally, I took an Erasmus year at EPFL (Suisse) to focus on composite science, looking at processing as well as mechanical investigation. I heard about natural fibres as a potential reinforcement for composites. I liked this idea and I find a 6 month internship in a Helvetic firm focusing on flax composites: Bcomp. Finally, curious about learning more about this material, I arrived in Lorient for this PhD. The following years still have to be written …

Keywords: *Biocomposites ; Interfaces ; Mechanical properties*

References

[1] D. Pantaloni, D. Shah, C. Baley, A. Bourmaud, "Monitoring of mechanical performances of flax non-woven biocomposites during a home compost degradation". *Polymer Degradation and Stability. 177 (2020).*

[2] A. Bourmaud, J. Beaugrand, D.U. Shah, V. Placet, C. Baley, "Towards the design of high-performance plant fibre composites". *Progress in Materials Science. 97 (2018) 347–408*

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Early-flowering hemp fibres for high-value textile or structural composites

Abstract

Hemp have been cultivated for a long time, in the past mainly for textile application and nowadays for seeds or paper pulp industry. In Western Europe, no production of long hemp fibres for textile is currently on-going. Many recent lab-scale studies reported that hemp fibres have a great potential for high-quality textile and composite industry. It was observed that the quality of the fibres is highly dependent on the agronomic practices, the pedoclimatic conditions and the variety. This work presents a case study carried out in Normandy which is the largest flax producer for textile fibre in the world. At the end of the summer the weather is very humid in that area so it is difficult to bale hemp stems in dry condition, which is crucial for avoiding the degradation of the fibres. An early-flowering hemp variety should then be chosen to meet the weather requirements of Normandy.

This work qualifies the yields and the properties of a monoecious hemp variety, named USO31, which has already been tested in preliminary tests in Normandy with success. Hemp plants were harvested on a large plot size and at the time of harvesting, stems were cut in two parts separating the top and the bottom halves. The dew-retting stems were then processed with an industrial flax scutching line with adapted settings. The yields are measured at different processed steps and the fibres division measurement is performed by analysing fibres bundles thickness using a high-resolution scanner and a dedicated image analysis software (FIBRESHAPES). Microstructural properties, such as fibres maturity, are studied by examining the stem cross-section with an optical microscope. Mechanical tests are carried out on single elementary fibres with a dedicated tensile test device from the Dia-Stron Company.

This work provides new results on plant cultivation and processing, plant fibres tensile and structural properties. High hemp fibres yield extracted with an industrial scutching line has been obtained as well as good tensile properties and fibres thickness suitable for textile processing. Thus, primarily favourable results on the production of long hemp fibres at a large scale in Normandy are reported in this study.

Keywords: Hemp fibres yield, High-quality textile, Fibres tensile properties

Biography

Lola Pinsard is a 24 years-old PhD student at the ENIT. After completing a Master degree in polymers chemistry at INP-ENSIACET engineering school in Toulouse, she joined the LGP in Tarbes at the beginning of the year to start a PhD in the bio-based composites and textile group supervised by Pr. Pierre Ouagne. Her research work focuses on hemp fibres and their transformations from the field to the fabric for textile applications. Her study area covers the hemp cultivation, hemp fibres extraction and properties, and textile processing.

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Biography

I am Victor Popineau, currently in third year of PhD at the IRDL in Lorient under the supervision of Antoine Le Duigou, Amandine Célino and Christophe Baley. My thesis is entitled: *Biocomposites reinforced with natural fibres: High mechanical performances and durability in marine environment.*

After finishing highschool in 2011, I attended the Classes Préparatoires aux Grandes Ecoles and was accepted in Ecole Centrale de Nantes (ECN) in 2013. I chose this school for its Hydrodynamic and Naval Engineering specialization, for I have been interested in sciences and nautism since I was young pupil. After finishing the specialization, I did a first engineer internship in a naval architecture firm in Nantes, France, and then a first research internship in the Maritime Research Institute Netherlands, in Wageningen, The Netherlands, during which I worked on computational fluid dynamics.

Afterwards, I took another specialization in ECN : Materials, Processes and Material Mechanics, after which I did another research internship, in the Institut Clément Ader in Toulouse, France, during which I studied the fatigue behavior of methan confinement materials.

As I got more and more interested in the research field, I chose to pursue my career with a thesis, which I started in IRDL, Lorient, after working 6 months in IRDL, Brest, as a research engineer.

Study of hygroscopic stresses with flax/MAPP biocomposites: evolutions through hygroscopic cycles

Abstract

Flax fibers are sensitive to the presence of water [1] and tend to swell or shrink with moisture variations. Therefore, flax fibers reinforced thermoplastic composites are subjected to hygroscopic stresses that influence their mechanical characteristics and can lead to macroscopic deformations and even failure of the parts [2].

This study aims to understand the development of hygroscopic stresses within flax reinforced polypropylene with maleic anhydride grafted polypropylene (flax/MAPP) biocomposites obtained with vacuum-bag-only molding and their evolution through hygroscopic cycles.

First, to study the hygroscopic and mechanical behavior of the biocomposite as a function of the moisture content, square unidirectional samples, along with longitudinal and transervsal unidirectional tensile samples are tested in the successive condtions : dry state (after 72h at 105°C in a vacuum oven), and after stabilization at 23 °C, at 11, 33, 56, 75, 98 %RH. The square samples are weighed and measured in the longitudinal, transversal and out of plane direction, so the hygroscopic behavior is extracted. The tensile samples give access to the mechanical behavior as function of the moisture content.

To study the evolution of hygroscopic stresses along hygrothermal cycles, $[90°]_9[0°]_3$ asymmetric laminates, along with longitudinal and transversal tensile samples are then divided in 3 batches and exposed to 3 different hygroscopic cycles : at 23°C, between 11 and 56 %RH, 56 and 98 %RH and 11 and 98 %RH. At each RH condition of the cycle, the samples are weighed until stabilization of the mass, the curvature of the asymmetric samples is then measured to deduce the stress state of the sample using laminate theory [3], and the samples are put in the other conditions. Once every a certain amout of cycles, the tensile samples are tested, in ordre to link the mechanical behavior and internal stress state.

The study shows that on the samples tested, the hygroscopic stresses develop in an elastic domain and that permanent hygroscopic stresses only develop at high moisture content. This study also show that the irreversible degradation appear progressively when the samples are exposed to several cycles at high moisture content.

This subject would certainly fit in the topic "*Manufacturing, design and durability*".

Keywords*: Biocomposites ; Internal stresses ; Hygrothermal ageing*

References

[1] Le Duigou A, Merotte J, Bourmaud A, Davies P, Belhouli K, Baley C. Hygroscopic expansion: A key point to describe natural fibre/polymer matrix interface bond strength. Compos Sci Technol 2017;151:228–33. https://doi.org/10.1016/j.compscitech.2017.08.028.

[2] Célino A, Fréour S, Jacquemin F, Casari P. The hygroscopic behavior of plant fibers: a review. Front Chem 2014;1. https://doi.org/10.3389/fchem.2013.00043.

[3] Péron M, Célino A, Jacquemin F, Le Duigou A. Hygroscopic stresses in asymmetric biocomposite laminates submitted to various relative humidity conditions. Compos Part A Appl Sci Manuf 2020;134. https://doi.org/10.1016/j.compositesa.2020.105896.

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Full-field 3D Strain Mapping of Flax Fibre Composites by Means of 4D X-CT Digital Volume Correlation

Abstract

Digital Volume Correlation (DVC) can be considered as the extended version to the 3D domain of the 2D strain mapping method of Digital Image Correlation (DIC), where the acquisition of the data is not limited to the sample's surface but can effectively give information regarding the internal deformation behavior throughout the volume of the material. The acquisition of the volumetric data is normally performed by means of micro-computed tomography (μ-CT) and similarly to DIC a high-contrast stochastic speckle pattern, often in the form of randomly distributed high-density micro-particles, is crucial in order to perform strong correlation between the reference and the deformed state. Although these particles can lead to high precision strain measurements, their inclusion can be challenging due to manufacturing dispersion difficulties or CT contrast shifts due to the high gap of density difference between the particles and the material of interest. In the present study, the natural texture of the material, more specifically the individual flax fibers, in the scans served as an adequate random speckle pattern for the analysis at the scale of interest. Hence, no particles were added to the material for speckling. This is possible due to the non-constant cross-section of flax which provides enough information for a high correlation. A preliminary analysis was performed to assess the precision and accuracy of the DVC and estimate the correlation errors using the "digital deformation" method. The method is based on the digital resizing of the image sequence gained from the reference scan, thus the applied deformation is known. Then, the reference and the digitally deformed volumes are being correlated and the predicted strain values are within the range of the applied "virtual" strain with low errors.

Keywords: X-ray computed tomography, Digital Volume Correlation, Strain fields

Biography

After obtaining my engineering diploma in Materials Science & Engineering from University of Ioannina, Greece, I decided to open up new horizons and pursuit a PhD in KU Leuven, Belgium, within the Marie Curie ITN Project "FibreNet", under the supervision of Prof. Dr. ir. Aart W van Vuure. My main research interests are focused on the durability of bio-composites particularly with thermoplastic matrices, moisture absorption and hygroscopic swelling, fibre-matrix degradation etc.

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Combined experimental and numerical approaches to grasp the mechanical behaviour of flax fibres and bundles

Abstract

The aim of my thesis project is to better understand the mechanical behavior of flax fibres and bundles, thanks to combined experimental and numerical approaches. In particular, the influence of defects is addressed by means of imaging techniques (polarized light microscopy, X-ray microtomography) and *in situ* mechanical testing, including the use of Synchrotron X-ray diffraction enabling to monitor the microfibril reorientation. The experimental results serve as building blocks of finite element models that look at different aspects of the mechanical behavior including elasticity and failure (Figure 1). The numerical approach provides a complementary understanding of the fibre structure at a local scale. It is of interest in order to better understand and tailor the properties of plant fibres at the composite scale. Further prospects regarding modelling will take into consideration the complex damage mechanisms leading to failure and the influence of the middle lamella at the bundle scale.

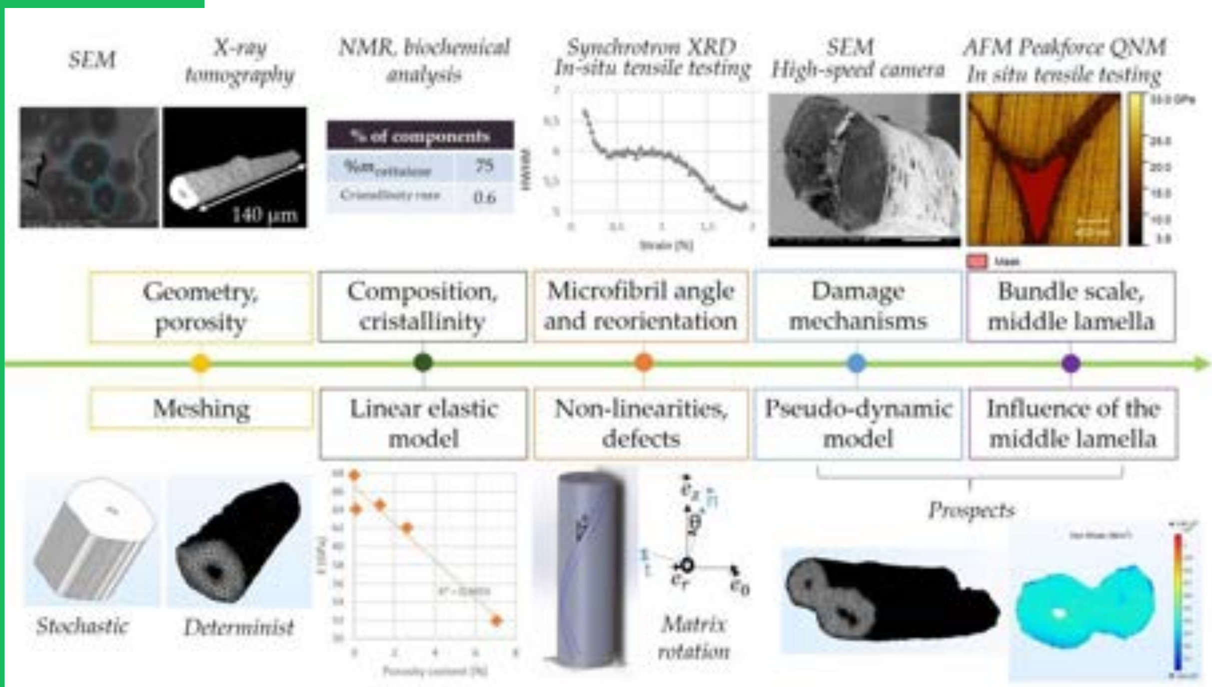

Figure 1: Modelling stages highlighting the experimental approach (upper part) linked to the related numerical approach (bottom); (SEM: scanning electron microscopy, NMR: nuclear magnetic resonance, XRD: X-ray diffraction, AFM Peak-force QNM: Atomic Force Microscopy, Peak-Force Quantitative Nano-Mechanical property mapping)

Keywords: flax, modelling, mechanical behaviour

Biography

After obtaining an engineering diploma from INSA Lyon in materials science in 2018 and gaining great interest in bio-based materials during an exchange year at KTH Stockholm, I am currently a phD student at BIA - INRAE Nantes. I work within the Interreg *Flower* project, with the aim to better understand the structure-behaviour relationship of flax at the fibre and bundle scale, by combined experimental and numerical approaches.

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From biobased synthons to more environmentally friendly biobased epoxy prepregs.

Abstract

Epoxy prepregs are commonly utilized for the ease of use and good mechanical properties. Nevertheless, the main issue with this kind of material lies in the need to keep a cold chain to prevent the polymerization reaction **[1]**. This cooling step is energy consuming, and its removal may be a key point in developing more environmentally friendly materials.

To make this change possible, it is required to decrease the reactivity of the prepolymer to allow room temperature storage. To perform this change, Fibroline, a French company, developed a process to replace the gel prepolymer by a powder. This powder is impregnated into the fibrous reinforcement by applying alternating electric fields, and fixed by thermocompression before the final shaping. This technique has many advantages: room temperature storage, no VOC, compatibility with plant fibres… The main restriction is the necessity to have a solid prepolymer at ambient temperature, and this powder has to present very particular thermal characteristics **[2]**. Some epoxy formulations already exist, but unfortunately, they all rest on petrobased molecules. In order to go further in the development of more sustainable materials, designing a fully biobased composite with a less resources consuming shaping is an enthralling challenge.

Our team previously showed how to prepare epoxy monomers derived from eugenol, a biobased molecule that can be extracted from lignin **[3]**. The polymerisation of the resulting BioIgenox leads to high glass transition **[4]**. However, this epoxy mixture is not solid at room temperature, like many others in biobased epoxy monomers field.

To expend the list of biobased formulations compatible with Fibroline's process, I developed during my PhD thesis a method allowing the use of BioIgenox in the formulation of powder prepolymer. Different strategies have been explored, and increasing the molar mass of the monomers appears to be the most promising way. To do so, BioIgenox was engaged in a polymerization reaction with a few percent of the required curing agent to obtain an oligomer in powder form. Then, the missing curing agent is added to complete the formulation. After grinding, the powder is ready to be used in the Fibroline's process, to impregnate plant fibre reinforcement, and then manufacture high performance fully biobased composites.

Keywords: Innovative process, Biobased composites, Polymer chemistry

Biography

Quentin Ruiz is a third year PhD student at the University of Burgundy. He received an engineer degree in materials from Polytech Montpellier in 2018. His current researches are focused on developing fully biobased composites by working on lignin-derived epoxy monomers.

Acknowledges

Q.R. is thankful for a PhD fellowship awarded by the Conseil Régional de Bourgogne-FrancheComté (France) and the European Regional Development Fund (FEDER) in the frame of the "*Jeunes Chercheurs Entrepreneurs*" program.

References

[1]: A. R. Pouladvand, M. Mortezaei, H. Fattahi, I. A. Amraei, *A novel custom-tailored epoxy prepreg formulation based on epoxy-amine dual-curable systems*, Comp. Part A, **2020**, 132, 105852, https://doi.org/10.1016/j.compositesa.2020.105852.

[2]: Fibroline's patents, see https://patents.justia.com/assignee/fibroline-france

[3]: C. François, S. Pourchet, G. Boni, S. Rautiainen, J. Samec, L. Fournier, C. Robert, C. M. Thomas, S. Fontaine, Y. Gaillard, V. Placet, L. Plasseraud, *Design and synthesis of biobased epoxy thermosets from biorenewable resources*, Comptes Rendus Chimie, **2017**, 20, 11–12, 1006-1016, https://doi.org/10.1016/j.crci.2017.10.005.

[4]: Q. Ruiz, S. Pourchet, V. Placet, L. Plasseraud, G. Boni, *New Eco-Friendly Synthesized Thermosets from Isoeugenol-Based Epoxy Resins*, Polymers, **2020**, 12, 229. https://doi.org/10.3390/polym12010229.

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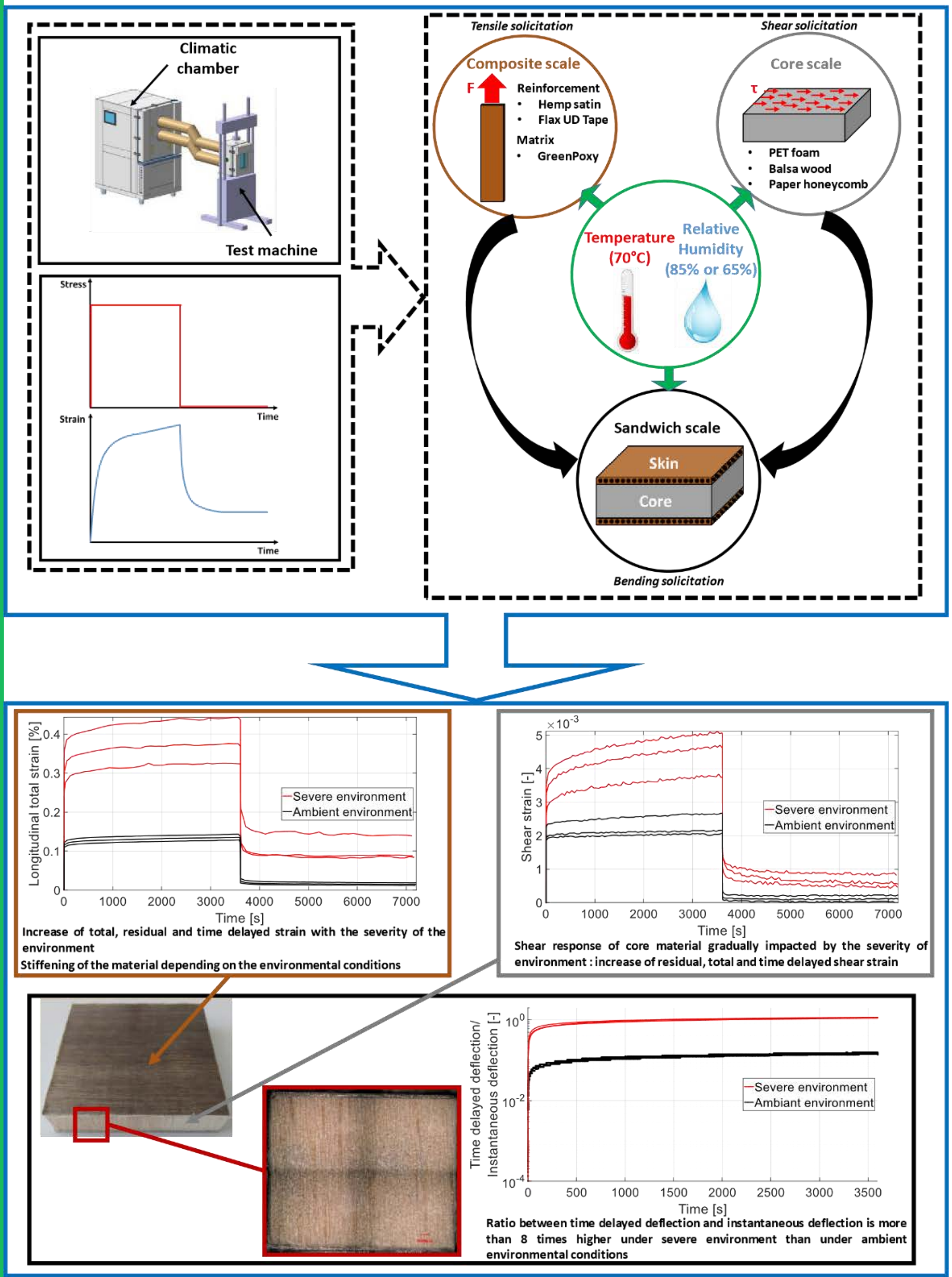
Creep behavior of bio-based sandwich structures under varying environment



Keyword: Bio-based sandwich, creep behavior, moisture content

Biography

Benjamin Sala graduated as an aeronautical engineer in the field of structures and materials from the École Nationale Supérieure de Mécanique et d'Aérotechnique (ISAE-ENSMA) in Poitiers (France). Having great interest in composite materials, he pursued his studies on this topic by doing a PhD thesis at the Department of Applied Mechanics of the FEMTO-ST Institute. He is working on the prediction of the creep behaviour of bio-based sandwich panels under varying environments in the framework of the European SSUCHY project.

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Analyzing Material Perception Of Biocomposites To Enhance Desirability And Distinguishability

Abstract

With the increasing global attention on sustainability, biocomposites are touted as a possible solution to deal with the issues of unsustainable raw material production, product manufacture and disposal. But after decades of research, and serious explorations in material chemistry, the tangible outcomes in terms of impactful raw materials are few and far. This paper proposes the idea that beyond functional aspects, the lack of widespread acceptance for biocomposites could be driven by their lack of desirability and distinguishability; and explores the key elements of visual perception which can make biocomposites an attractive choice for product manufacturers.

Material perception is created by a combination and interaction of neural signals, contextual information and past experiences acquired by the observer. Factors creating 'good' material experiences are studied through various established models of natural and evolutionary aesthetics. Material characteristics attributing 'naturality' to materials, including material, product, contextual and intangible aspects are investigated to identify and abstract the key elements driving material perception. Comparisons between various frameworks of material perception and pleasurable material experiences are conducted and factors correlated to derive components for an ideal material experience.

Based on a review of the literature on human perception and evolutionary aesthetics, three categories of material attributes are identified- Somatic attributes, Usability/Experience attributes and Semiotic attributes- which forms the building blocks of materiality in product perception. This paper focuses on the perceptual attribute components of materials and explores how biocomposites could be made desirable and distinguishable by modifying the physical characteristics and these perceptual attributes associated with them. Favourable perceptual attributes like evidence of natural life, permanent aesthetics (timelessness), gestalt's principles, abstraction, novelty-familiarity balance, etc are considered in the context of natural materials. Translating these material characteristics into biocomposites or products manufactured from biocomposites through chemical formulations, additives or processing techniques could lead to their broader acceptance into product manufacturing industries.

Keywords: Biocomposites-Aesthetics-Material Perception

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Mechanical characterization of a PHA bio-composites based on natural Alfa fibers

Abstract

Composite materials based on natural fibers are today enjoying growing success in all industrial sectors. Natural fillers are inexpensive, abundant, recyclable and have excellent mechanical properties due to their low densities. They are widely used for technical applications such as transport, construction, packaging and can be also applied in nautical structures. The main purpose of this study is to elaborate PolyHydroxyAlkanoates (PHA) bio based composite reinforced with natural Alfa fibers. In this work, cellulose fibers were first extracted from Alfa stems using alkaline methods. Fibers after extraction were next modified through bleaching treatment using Sodium Hypochlorite $NaClO_2$ to increase cellulose level. PHA/Alfa bio-composites with reinforcement rates up to 30% of fibers were then elaborated. The influence on the mechanical behavior of the fiber content was studied by carried out tensile tests under different loading conditions (monotonic, cyclic and interrupted by relaxation steps). The final goal is to find the material parameters of a constitutive model named HVH able to describe the Hyper-ViscoHysteresis behavior of this bio-material.

Keywords: Bio-composite; PolyHydroxyAlkanoates, Alfa Fibers.