Waste biorefinery technologies for accelerating sustainable energy processes

Book of abstracts

WIRE's 4th Working Groups Workshop

Brandenburgische Technische Universität Cottbus-Senftenberg (BTU)

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Waste biorefinery technologies for accelerating sustainable energy processes

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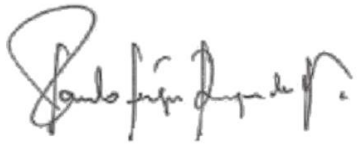
Message from the Action Chair

The need to have a sustainable society in environmental, economic and social terms involves the way we produce and use resources, how we produce and use energy, and the way we produce our materials and products. Answering such questions requires a constant search for research, creation of knowledge and innovation in new energy sources and systems, as well as more efficient and effective use of our resources. Waste material biorefineries are a path that allows achieving these goals; however, it requires an effort to integrate scientific, technical, and economic knowledge to create technological innovation, territorial development, and the valorization of resources.

Knowledge and experience networks are essential for developing this approach in Europe and the world. WIRE is an example of these networks that we have been developing with the support of the COST program. WIRE's 4th Working Groups Workshop, where very relevant technological studies were presented, is another step in consolidating this strategy.

To researchers, entrepreneurs, and political decision-makers, I challenge you to join this network so that you can contribute and receive what we have already managed to gather.



Paulo Brito, Action Chair

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Introduction

By 2030, the bio-based economy is expected to have grown significantly in Europe. One of the pillars of this bioeconomy is the concept of BIOREFINERY, the sustainable processing of several kinds of waste and biomass into a spectrum of marketable products and energy. While in the past many research efforts have been conducted toward understanding, mode ling, and designing conversion processes that can sustain a true circular economy, this KNOWLEDGE IS QUITE FRAGMENTED and UNEVENLY DISTRIBUTED across Europe. Several countries lack proper policies and public engagement to address the challenges ahead. HARMONIZATION must start with ROBUST KNOWLEDGE and the ability to cover the WHOLE VALUE-CHAIN, from source materials up to the marketable products… and that is WIRE's mission.

The WIRE COST Action broadly organizes into 4 KEY WORKING GROUPS (WG) that bring together experts from ACADEMIA, INDUSTRY and TECHNOLOGY TRANSFER organizations:

- WG 1: Raw Materials
- WG 2: Biorefinery Conversion Technologies
- WG 3: Biorefinery Applications
- WG 4: Communication and Dissemination

WIRE's MC Meeting & 4th Working Groups Workshop was held in Cottbus (Germany) at the Brandenburgische Technische Universität (BTU) from 04 to 05 October 2023.

The main objective of this workshop was to increase the participation of WIRE members through sessions and industry tours, poster presentations by participants, as well as two lectures and WG meetings.

This event contributed to advancing the goals and deliverables of each WGs and promoting interaction between WG´s participants and stakeholders.

WIRE's MC Meeting & 4th Working Groups Workshop had 53 papers presented as oral and poster communications, divided among the different WGs.

Production of residues: Portugal case study

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Abstract:

This is a comprehensive study on waste production in a small country, Portugal, and the destinations of waste generated in this country. In recent years, there have been substantial changes in legislation both at national and European level, regarding energy production and waste management. Thus, advances in waste recovery technologies have become essential, as well as in the recovery of by-products from these processes. The two most representative groups of waste are municipal solid waste and biomass waste. The total production of municipal solid waste in Portugal in the year of 2021 reached approximately 5.04 million tons. Concerning biomass waste in mainland Portugal it is thought that there are approximately 6.5 million tons of biomass waste available per year. Another of the most important residues in Portugal is olive pomace. It is estimated that in the years 2019-2020 was produced around 658 thousand tons of olive pomace in this country. Therefore, all these concepts are directly related to the valorization and it is of the utmost importance to understand the waste paradigm. It is also very important to understand the amount of waste available in each country so that it is possible to assess its availability for potential recovery.

Details of presenting author

Name: **Ana Carolina Assis**
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Short biography: Ana Carolina Assis has a degree in Chemistry (UÉ, Portugal), a Master degree in Materials Chemistry (UÉ, Portugal) and at these moment is a PhD student in Chemistry (UÉ, Portugal). She has a research grant for PhD in VALORIZA (Research Center for Endogenous Resource Valorization). Her main research interests are related to bioenergy, waste management and thermochemical valorization, materials, production of renewable gases and above all valorization of by-products from thermochemical processes. She has published in conferences, journals and participated in multiple events in her area of expertise (https://orcid.org/0000-0001-5784-1319).

A straightforward approach to fabricate photocatalytic materials using composite nanocellulose aerogels: Application in atmospheric environmental remediation

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Abstract:

In this study, we present a novel and environmentally conscious approach to prepare nanocellulose/TiO_2-based aerogels for the efficient removal of nitrogen oxide (NO_x) emissions, a process known as De-NO_x action. As the environmental impact of NO_x emissions becomes increasingly concerning, developing effective and sustainable methods for their abatement is crucial. To achieve this, we employed an innovative valorization strategy that harnesses agricultural waste as a valuable resource. This approach allowed us to successfully formulate hybrid structures using a simple colloidal route based on a heterocoagulation process between delignified cellulose nanofibers (CNFs) and TiO_2 nanoparticles (TiO_2 NPs). The combination of nanocellulose and TiO_2 materials creates a synergetic effect that enhances the photocatalytic performance, making it a promising solution for NOx removal.
The nanocellulose aerogel acts as a three-dimensional support for the photoactive phase, providing a large surface area for the catalytic reaction. Moreover, this unique structure facilitates efficient light absorption and reactive gas diffusion, further enhancing the overall photocatalytic activity. Under light irradiation, all samples exhibited a positive response in NO abatement. Remarkably, the CNF100 sample displayed the best selectivity (82%) and the highest efficiency (78%) for NO removal, resulting in an outstanding NOx efficiency of 64%. These results significantly outperformed the conventional TiO_2 P25 powder photocatalyst. Beyond its superior performance, our nanocellulose/TiO_2 aerogel system contributes to sustainable development by utilizing agricultural waste. The process not only promotes the valorization of this waste but also minimizes the environmental impact of waste disposal.
In conclusion, our study highlights the potential of nanocellulose/TiO_2-based aerogels as highly effective and eco-friendly materials for photocatalytic De-NO_x applications. The combination of nanocellulose and TiO_2 showcases remarkable synergistic effects, resulting in superior NO_x removal efficiency compared to traditional TiO_2 photocatalysts. We envision that this approach can play a crucial role in addressing the challenges of NO_x pollution, contributing to cleaner and healthier environments. Moreover, the integration of agricultural waste valorization makes our method a sustainable and economically viable solution for future environmental applications.

Details of presenting author

Name: **Eduardo Espinosa**
Affiliation: BIOPREN Group, Chemical Engineering Department, University of Córdoba
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Short biography: Assistant Professor at the Department of Chemical Engineering. He has published more than 40 peer-reviewed articles (>65% in Q1) mainly related to the processing and application of cellulose and derivatives for the production of advanced materials. Since 2014 he has been part of the research team of more than 8 projects funded in public-private calls, mainly focused on the application of lignocellulosic materials for the development of sustainable packaging solutions. Author of a patent on the use of cellulosic fibers obtained from agro-industrial waste for the production of food trays. He has participated as an expert evaluator in several international projects.

Lignin nanoparticles with entrapped *Thymus* spp. essential oils for the control of wood-rot fungi

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Abstract:

After decades of utilization of fossil-based and environmentally hazardous compounds for wood preservation against fungal attack, there is a strong need to substitute those compounds with bio-based and circular solutions, such as bioactive essential oils and renewable and abundantly available lignin, which often derives from waste biomass. In this work, lignin nanoparticles containing essential oils from different thyme species were applied as biocide delivery systems in in vitro experiments to test their anti-fungal effect against two white-rot fungi (*Trametes versicolor* and *Pleurotus ostreatus*) and two brown-rot fungi (*Poria monticola* and *Gloeophyllum trabeum*). Entrapment of essential oils in a lignin carrier matrix provided a delayed release over a time frame of 7 days and resulted in lower minimum inhibitory concentrations of the essential oils against the brown-rot fungi (0.30–0.60 mg/mL), while for the white-rot fungi, identical concentrations were determined compared with free essential oils (0.05–0.30 mg/mL). Fourier Transform infrared (FTIR) spectroscopy was used to assess the fungal cell wall changes in the presence of the lignin nanoparticles loaded with essential oils in the growth medium. The results regarding brown-rot fungi present a promising approach for a more effective and sustainable utilization of essential oils against this class of wood-rot fungi when being applied in a lignin-based delivery system.

Details of presenting author

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Short biography: Florian Zikeli has been working with lignocellulosics since his PhD thesis in 2010, which he conducted both at TU Wien and KTH Stockholm. He was working especially with lignin isolation and characterization using NMR spectroscopy, UV spectroscopy, molar mass analysis via HPSEC, and wet chemistry methods. From 2017, he has worked as a Post-Doc in Italy, University of Tuscia in Viterbo, studying lignin nanoparticles for wood-related applications such as biocide delivery systems or surface treatments. From 2020, he was a research assistant at TU Wien for almost two years, before he went back to University of Tuscia to start in a researcher position.

Refuse derived fuel char - A promising energy resource

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Abstract:

One of the main barriers to energy or material recovery from waste is the poor knowledge of its potential and applicability. Waste carbonization is considered a process to improve the quality of waste and produce a value-added product, char. This study aimed to investigate carbonization as a pre-treatment process for refuse-derived fuel (RDF) and its influence on the combustible characteristics of RDF, such as bulk density, ash and chlorine content, and heating value. For the carbonization tests, the influence of the temperature and residence time on the char characteristics was evaluated. The results indicated an increase in the ash content with increasing temperature and residence time. The raw RDF contained 15% ash, and the chars obtained at 300°C for 1 h, 400°C for 30 min, and 400°C for 1 h were approximately 16%, 22%, and 26%, respectively. The chars obtained had a higher chlorine content and heating value than the raw RDF. The heating value of the chars was as high as 26% higher than that of the raw RDF. Regarding the bulk density, the raw RDF was approximately 0.175 g/cm^3, while the chars were approximately 0.419-0.476 g/cm^3, approximately 139-172% higher, respectively, than the raw RDF. The increase in ash and chlorine content may be one of the limitations of the energy application of these chars, therefore, a comprehensive study of the concentrations of these parameters that are acceptable for energy processes is needed. In general, the RDF chars obtained showed high heating value and bulk density, overcoming the issues of ash and chlorine content, these chars exhibit good potential for energy applications.

Details of presenting author

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Short biography: Santa Margarida dos Santos has a degree in Renewable Energy and Environment Engineering from the Instituto Politécnico de Portalegre and Master in Bioenergy from the Faculdade de Ciências e Tecnologia of the Universidade Nova de Lisboa. Has developed research work in Research Fellowships (PoliTechWaste and AmbWTE projects) in waste recovery, bioenergy, and renewable gases trough gasification. In terms of publications, she has 3 journal article, 6 conferences paper, 2 poster and 5 oral presentations. More recently she started her PhD in Bioenergy where she will study the valorization of Refuse Derived Fuels (RDF) through gasification to produce value-added products.

Olive pomace waste raw material as biochar precursor for arsenic adsorption

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Abstract:

Olive oil production is one of the oldest biorefining processes in the Mediterranean. This process has evolved to become more efficient, but it still generates large amounts of waste in the form of olive pomace, which urgently needs to be harnessed and valorised. The BIOAs is a LIFE project aiming to demonstrate the environmental and economic feasibility of a process for the production of an innovative bio-adsorbent and, simultaneously, its use for the purification of drinking water from arsenic and other pollutants. The focus of the project will be the demonstration of a process to produce an innovative bio-adsorbent by the hydrothermal carbonization of the olive pomace (a by-product of the olive oil production industry) at a cost at least 50% lower, as compared to the conventional employed adsorbent GFH (Granular ferric hydroxide) and, simultaneously, its use for the water purification in line with the EU Directive of drinking water from arsenic. The LIFE BIOAs project involves six partners in Italy and Portugal. The planned actions of the LIFE BIOAs project will contribute to the implementation of the 6, 9 and 12 ONU objectives for a Sustainable Development for the Agenda 2030.

Details of presenting author

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Affiliation: MED – Mediterranean Institute for Agriculture, Environment and Development & CHANGE – Global Change and Sustainability Institute, Departamento de Química e Bioquímica, Escola de Ciências e Tecnologia, Universidade de Évora and VALORIZA – Research Centre for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, Campus Politécnico 11, 7300-555 Portalegre, Portugal
Country: Portugal

Short biography: Paulo has a Physics and Chemistry graduation, a master in Physics, and a PhD in Chemistry, Materials and Surface area. In the last years he has consolidated his research in the fields of preparation, characterization, development, and application of porous materials, with the focus on the recovery and valorization of different raw materials and waste, from natural and/or synthetic sources, by its transformation into adsorbents with potential application in the liquid and gas phases, guided by a circular economy perspective. This knowledge and experience provide potential contributions in the areas of water treatment (e.g., drinking and wastewater), space management through the valorization of by-products and waste, of natural and synthetic origin, for use in the preparation of value-added materials (with multiple applications), among others (https://orcid.org/0000-0002-3634-2390)

Unlocking the potential of wastes: Enhancing biofinery processes through pretreatment and disintegration

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Abstract:

Wastes is the new resource! Waste materials are emerging as valuable resources, because they keep increasing no matter what is done for sustainability. This also presents a unique challenge due to diverse composition and amount of wastes. The optimization of waste utilization in biofineries demands meticulous process design to yield targeted products. This necessitates a preliminary pretreatment phase to effectively prepare waste streams by separation and disintegration, streamlining subsequent main processes. Our investigation, as part of COST WIRE project, focused on role of temperature in disintegrating essential building blocks (e.g., proteins, polysaccharides) before the production of biomethane or bioplastics. Results highlight the efficiency of mixed cultures in methane generation using waste activate sludge. However, the success of bioplastic-producing microorganisms hinges on factors like raw material type, processing conditions, and pretreatment methods. Although comparatively expensive compared to conventional manufacturing processes; our findings favor the energy-centric approach-energy production from waste streams. This study underscores the critical significance of tailored pretreatment strategies in biofineries, paving the way for sustainable waste-to-product transformations. Our research highlights the importance of intricate dynamics governing waste-to-energy and waste-to-product transitions.

Waste biorefinery technologies for accelerating sustainable energy processes

Diverse definitions and the quest for unity: Exploring biomass terminology

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Abstract:

Currently, different biomass definitions are used at national levels and in addition, these definitions are frequently modified on “need basis”. European Union's (EU) Directive 2018/2001 defines 'biomass' as the biodegradable fraction of products, waste, and residues originating from agriculture, including vegetal and animal substances, as well as forestry, related industries, fisheries, and aquaculture. Additionally, it encompasses the biodegradable portion of waste, including industrial and municipal waste of biological origin. The OECD and EEA endorse the definition of biomass presented in Directive 2001/77/EC of the European Parliament and the Council, dated 27 September 2001, which promotes renewable electricity production within the internal electricity market. Biomass defined as “the biodegradable fraction of products, waste and residues from agriculture (including vegetable and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste. Bias interpretation of the biomass definition in Türkiye highlights the need for a unified biomass definition. Biomass term entered the Turkish legislation for the first time through Law No. 5346, 'Use of Renewable Energy Resources for Electricity Generation'', which was adopted in 2005. In its initial version, this law was defining biomass as 'solid, liquid, and gaseous fuels obtained from agricultural and forest products, including by-products resulting from their processing. This encompasses vegetable oil waste, agricultural harvest residues, and organic waste.' In its current context, old tyres are included/classified as biomass, to take advantage of the incentives for incineration and pyrolysis applications. Earlier, the divergence in biomass terminology among countries and institutions drew the attention of the UN Food and Agriculture Organization (FAO), also. In 2004, FAO emphasized the importance of unified biomass terminology and introduced a roadmap through the 'Unified Biomass Terminology' report. As part of the dissemination activities within Working Group 4 (WG 4), we are curating a comprehensive database that will collect and compare 'definitions' pertinent to biorefinery-related research.'' We anticipate that the findings of this study will carry global significance, offering valuable insights for fostering the sustainable evolution of the biorefinery paradigm.

Biological and biochemical alleviation of ammonia toxicity in in continuous biomethanation reactors

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Abstract:

Biorefinery focused research has intensified in its every aspect, in recent years. Several promising technologies and processes investigated, which may find use in biorefineries, in the near future. The economics of biorefineries and resource optimisation are also evaluated academically. The discussions that highlight the critical approaches in building biorefineries include not only the type, amount of biomass and their locations but also a common base of knowledge and quantification methodology. Each country needs to identify the biomass, related region and the product(s), which can provide critical amount of resource for sustainable development. It is also necessary to define internationally accepted management basics for biorefineries, which all starts with establishing national and international technical common grounds. COST-WIRE project creates an effective platform for these discussions. In this paper, we share our research findings conducted as part of WG4 activities, which aim to evaluate resource (biomass) potentials and their distribution at national level for sustainable operation of biorefineries. Resource identification and their distribution is mainly handled in WG1 of the COST-WIRE project. On the other hand, a methodology for the dissemination of the knowledge is the responsibility of WG4, and we would like to discuss methodology. The report "*EU Biorefinery Outlook to 2030*" prepared by EU in 2021 also falls short to address this issue. We used Türkiye as the model country and we believe that our approach will be instrumental to address similarities and differences in biomass quantification and location, in each European country. This and other similar studies are necessary to disseminate biorefinery knowledge and optimized biorefinery management in Europe. Türkiye has an annual more than $65x10^6$ tones of non-food cereal production. Our current calculations show that an additional $21x10^6$ tones of biomass production potential comes from the edible wastes. The biomass production of Türkiye from forestry industry exceeds $200x10^6$ tons, annually (a detailed methodology/data will be given during the talk). These results indicate that more than one biorefinery model for Türkiye or any other country must be evaluated, given that the biomass is not homogenously available in any country. In addition the product line have to aim for high value Added Products. Currently, the priority and the uses of biomass have different purposes, in Türkiye. Different ministries manage the biomass data in Türkiye. Some of the data has a history of more than ten years whereas some is limited to recent years. Data sources are not linked or may not be compatible, as a result, actual biomass amount cannot be accurately predicted. The methodology to quantify the amount is also not common. Similar challenges, barriers to the establishment of biorefineries, can also be extrapolated to other countries, as well. Management of biomass is impeded by lack of administrative infrastructure at the national level, not to mention the challenge of establishing international principles with other

countries. Our methodology will serve as a common tool to prepare databases and overcome the challenges, internationally.

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Short biography Prof. Dr. Selim L. Sanin has a Ph.D. from DUKE University, (NC, USA), currently teaches and conducts research in the department of Environmental engineering. His research focuses on use of microbial systems in environmental engineering applications. He works on developing and modeling self-sufficient and economically feasible operational units, such as MFC, advance oxidation systems. He works on implementing these engineering systems in in-situ or on-site remediation applications for sustainable resource recovery applications.

Waste biorefinery technologies for accelerating sustainable energy processes

Microbial biominerals: the challenges to resource recovery

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Abstract:

Bacteria produce biominerals as a result of detoxification strategies, metabolic processes, controlled biomineralization (e.g. magnetosomes) and as an end product of anaerobic respiration (bacteria generate cellular energy by using various metals and metalloids as terminal electron acceptors, oxidizing organic and inorganic compounds to release and convey electrons via electron transport chains). Apart from fundamental aspects, the production of microbial biominerals may be relevant in the context of circular economy by recovering various soluble metals and metalloids from industrial effluents as solid minerals. This paper presents original results on the microbial biomineralization of i) lead (Pb) and ii) arsenic (As) and selenium (Se) and will explore the current limitations of recovering these resources.

i) Pb biomineralization was investigated using *Bacillus* sp. Abq (*Bacillus cereus*). The bacterial strain precipitates soluble Pb(II) to the black PbS mineral (galena) using cysteine as a source of hydrogen sulfide (H_2S)[1] . Cysteine is degraded intracellularly and then is exported to the extracellular environment to react with Pb(II). The mineralogy of biogenic PbS was confirmed by XRD, HR-TEM and EDX. Electron microscopy and electron diffraction identified crystalline PbS nanoparticles with a diameter <10 nm, localized in the extracellular matrix and on the surface of the cells. This is the first study demonstrating the use of cysteine in Pb(II) precipitation as insoluble PbS and it may pave the way to PbS recovery from secondary resources, such as Pb-laden industrial effluents.

ii) Bacteria play crucial roles in the biogeochemical cycle of arsenic and selenium as these elements are metabolized via detoxification, energy generation (anaerobic respiration) and biosynthesis (e.g. selenocysteine) strategies [2,3]. In this study [2], the anaerobic metabolism of As and Se in *Shewanella* sp. O23S was investigated with an emphasis put on the biomineralization products of this process. Multiple analytical techniques including ICP-MS, TEM-EDS, XRD, Micro-Raman, spectrophotometry and surface charge (zeta potential) were employed. Shewanella sp. O23S is capable of reducing selenate (SeO_4^{2-}) and selenite (SeO_3^{2-}) to red Se(-S)^0, and arsenate (AsO_4^{3-}) to arsenite (AsO_3^{3-}). The release of H_2S from cysteine led to the precipitation of AsS minerals: nanorod AsS and granular As_2S_3. All biominerals were extracellular, amorphous and presented a negative surface charge (-24 to -38 mV). It is worth mentioning that *Shewanella* sp. O23S shows high potential for use in bioremediation strategies to clean up real metal-laden industrial effluents [4]. This study provides evidence about the mixed microbial metabolism and the biomineralization of arsenic and selenium, and opens future research directions on the enzymatic systems and genetic determinants controlling this process with potential bioremediation and resource recovery applications.

[1] Staicu et al. (2020) PbS biomineralization using cysteine: *Bacillus cereus* and the sulfur rush. FEMS Microbiology Ecology 96(9) fiaa151 https://doi.org/10.1093/femsec/fiaa151
[2] Staicu et al. (2023) Interplay between arsenic and selenium biomineralization in *Shewanella* sp. O23S. Environmental Pollution 306:119451 https://doi.org/10.1016/j.envpol.2022.119451
[3] Barton et al. (2023) Genomic insight into iron acquisition by sulfate-reducing bacteria in microaerophilic environments. Biometals 36(2):339-350 https://doi.org/10.1007/s10534-022-00410-8
[4] Staicu et al. (2021) Bioremediation of a polymetallic, arsenic-dominated reverse osmosis reject stream. Letters in Applied Microbiology 75(5):1084-1092 https://doi.org/10.1111/lam.13578

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Short biography**:** I am researcher at Department of Bacterial Genetics, Faculty of Biology, University of Warsaw (Poland), working on microbial biotechnology and geomicrobiology. I am particularly interested in the interaction of bacteria with metals (biomineralization, detoxification and respiration) and the production of (bio)minerals having high-industrial value (e.g. Se^0, PbS, $BaSO_4$). Another research directions we are pursuing is the bioremediation of metal-rich industrial effluents such as those generated by the mining industry and the chemical recovery of barite ($BaSO_4$), a Critical Raw Material (CRM) in the European Union. More info about our research interests and output can be found at https://staiculab.com/

Development of the integrated organic waste management model using the circular economy's guiding principles

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Abstract:

Inadequate organic waste management, as defined by the linear economy theory, results in the production of new waste as well as the immobilization of nutrients and chemical energy, which are therefore inaccessible for reuse since they are not part of the natural processes of matter circulation. The concept of "circular economy" (CE) is applied in an integrated organic waste management system in a particular area, allowing the use of energy and the return of nutrients to nature with the generation of less new organic waste. The development of a model for integrated organic waste management and the analysis of the feasibility of incorporating the maximum amounts of organic raw materials produced in one territory into the circular economy-compliant organic waste management system are both included in this study. To evaluate the effectiveness of the circular economy's adoption and application, various CE indicators will be established.

Details of presenting author

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Short biography: Ana Momilović graduated from the Faculty of Mechanical Engineering at the University of Niš. In 2015, she completed her master's studies at the Faculty of Mechanical Engineering at the University of Niš. In 2017, she completed her master's degree in engineering management. She is a PhD candidate from the same university with a focus on circular economy. She speaks English, Russian, German, and Italian with ease.

Optimization of bioethanol production from agro-industrial wastes and by-products

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Abstract:

Over the last several decades, society has grown more concerned with sustainability and environmental challenges. Biomass represents one of the most important renewable resources for the future, and agro-industrial wastes and by-products have a great potential to produce sustainable bioproducts and bioenergy. Bioethanol produced by biomass fermentation represents a modern form of energy and a significant fossil fuel replacement. A wide range of raw materials can be used in fermentation, such as sugar beet or sugarcane juice and molasses (sugar-based), corn and wheat (starch-based), and bagasse and wood (cellulosic). Conventional production is based on corn, grain, and sugar-based raw materials. However, bioethanol production from by-products of various industries or waste lignocellulosic or starch-containing raw materials is developing. Many factors, such as temperature, sugar concentration, pH, fermentation time, and agitation rate, influence the bioprocess of bioethanol production, and to achieve the highest product yield, it is necessary to optimize the overall bioprocess and this research aimed to optimize different stages of the bioethanol production process from the selected agro-industrial by-product. Optimization by using the experimental design methodology and statistical approaches is a common practice in biotechnology. Response surface methodology (RSM) is the most common optimization technique based on essential statistics principles, which aim to execute experimental planning, build empirical models, and evaluate the effect of independent variables on the desired variable response. It has important applications in designing an experiment, developing and designing a new product, and optimizing existing products and process designs. By performing a bioprocess under optimal conditions, bioprocess kinetics can be defined, which is important for understanding, designing, and controlling the biotechnological process.

Details of presenting author

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Short biography: Bojana Bajić (PhD in Technological Engineering) is an associate professor in the field of Biotechnology (Bioprocess engineering, Bioreactors, Bioprocess design, Biomass as energy source) at the Department of Biotechnology at the Faculty of Technology Novi Sad, University of Novi Sad. Her research focuses on bioprocess development through optimization, modelling and simulation, specifically application of various waste and by-products of different industries for the production of biofuels, biopolymers and bioactive substances for crop protection.

Waste biorefinery technologies for accelerating sustainable energy processes

Bioenergy production and net-zero carbon dioxide emissions investigation for the upgrade of a small-scale biomass production unit with a biorefinery system

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Abstract:

The European Union (EU) has renewed interest for the wider use of biomass for bioenergy production and biorefinery applications, in order to meet net-zero carbon dioxide (CO_2) energy production by 2050. There are prospects for distributed exploitation of existing biomass production units, which can be integrated with candidate biorefinery technologies for bioenergy production resulting in reduced CO_2 emissions. The first objective is the review of woody biomass use in EU, with emphasis in local applications of woody biomass. The second objective is illustration of existing biorefinery technologies that can be integrated in woody biomass production units, in order to reduce CO_2 emissions generated by the biomass production units. The last objective is to apply a methodology for the estimation of the energy requirements and the generated CO_2 emissions by a local small-scale biomass production unit, and furthermore evaluate the avoidance of CO_2 emissions by implementing a biorefinery system for syngas production as an upgrade to the existing unit. The case study of the present work concerns a small-scale production unit of pellets located in the rural area of the district of Nicosia in Cyprus. The unit receives wood chips, pruning, biowaste from gardens, forests and local wood industry, and around 900 tonnes of pellets are annually produced by the unit, which has a total nominal installed power of 270 kW for the operation of its equipment. The electricity used by the unit is supplied from the national electricity grid, while there is the capability for the unit to produce syngas from an existing carbonisation constant volume furnace. The syngas can be utilised for local electricity generation, and the present work examines three test cases for bioenergy production, namely internal combustion engine, gas-turbine and combined-cycle power plant for power generation. The methodology which is adopted in the present work includes energy and mass balances for the operating equipment of the unit and the produced pellets energy content, along with the stoichiometric combustion equation for fossil fuels and biomass pellets with mass balance for the generation of CO_2 emissions of the existing unit, and the envisaged avoidance of CO_2 emissions, when each of the three test cases is employed using syngas produced by the furnace. For the calculations and analysis of the present work operational data is obtained from the unit and published data is selected for the lower heating values and molecular weight of the heavy fuel oil and biomass pellets with general compound C_aH_b and $C_aH_bO_c$, respectively. For the type of local production unit and its intermittent form of operation, the most feasible power generation technology is suggested, while the furnace biorefinery system is also discussed and other candidate biorefinery systems are further recommended. The results of the present work provide guidelines for future large-scale technology selection and development for bioenergy

production and reaching net-zero CO_2 emissions. Overall, it is concluded that biomass utilization is a promising solution for sustainable bioenergy production, when woody pellets are produced for heat while a biorefinery system produces syngas for power generation.

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Short biography: Dr. Charalambos Chasos currently holds the position of Associate Professor in Internal Combustion Engines (ICE) at the Mechanical Engineering Department of Frederick University. Dr. Chasos' current research includes CFD modelling, simulation and validation of fuel injection from high pressure Diesel, gasoline and gas injectors in combustion chambers, and CFD simulation of combustion phenomena for conventional and alternative fuels (biodiesel, bioethanol, biogas, natural gas, hydrogen and ammonia) in ICE. Dr. Chasos is a member of the Management Committee of the COST Action CA20127, “Waste biorefinery technologies for accelerating sustainable energy processes (WIRE)” for the period Oct. 2021 to Sept. 2025.

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Waste biorefinery technologies for accelerating sustainable energy processes

Olive bagasse and pig farming effluents as feedstocks for biorefinery concepts

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Abstract:

In order to mitigate the consumption of large amounts of energy and resources; it is of great importance to find sustainable ways for an effective management of different types of residuals arising from residential areas such as kitchen waste (KW) and municipal solid waste (MSW) along with primary sludge (PS) produced at wastewater treatment plants (WWTPs). Here, KW is mostly organic waste (i.e., consists of fruits and vegetable wastes, waste oils or greases, and cooking waste from food processing) with high putrefaction characteristics. On the other hand, MSW consists of several types of wastes (e.g., organic matter from food waste, paper and packaging wastes, yard waste, plastics, metals, textiles, and other miscellaneous items) which is continuously produced in high quantities. Hence MSW, the largest component of which is organic matter makes solid waste management a major environmental concern around the world. In this context, the use of disposers is proposed as a sustainable source reduction and waste minimization alternative by mixing the bulk of the organic fraction of MSW (OFMSW) with domestic wastewater before reaching the sewage and ultimately WWTP. As a result of KW disposer application, the chemical oxygen demand (COD) and total suspended solids (TSS) of the influent might increase by almost 50%. Moreover, since the separation of a considerable fraction of the organic-putrid food waste with substantial water content out of the entire MSW stream is possible, the average moisture in the remaining MSW as well as the leachate amount could be reduced at a great extent. The PS, on the other hand, is also comprised mainly of settled organic materials from raw sewage and food waste which is dominated by proteins, carbohydrates, and fats. Therefore, since all these waste types from residential facilities are rich in organic content; anaerobic digestion (AD) becomes as the most sustainable and feasible method for the minimization and reuse of these residuals by providing efficient volume reduction, effective stabilization, substantial biomethane provision from the carbonaceous compounds, and sufficient energy recovery from biogas. On the other hand, sewage sludge occurring at municipal WWTPs is considered as one of the most appropriate co-substrates for co-digestion with OFMSW; hence, AD also allows stabilization of these different large waste streams in the same bioreactor without any considerable additional investments enabling cost-effective and energy self-sufficient municipal WWTPs.

The aim of this study is to present an energy efficient municipal wastewater treatment involving anaerobic co-digestion of PS and OFMSW by the integration of KW for better valorization of these organic-rich residuals especially at large WWTPs in metropolitan cities like Istanbul. In this scope, potential biomethane (CH_4) production and net energy (electricity + heat) generation were determined for a population equivalence of 1 million people and for a daily water consumption of 0.25 m^3 per capita. During calculations, daily MSW generation was assumed as 1500 g per capita

on average. The KW integration ratio was taken as 40% and increase in the influent flow-rate was considered as 3% with disposers. According to the calculation-based results, daily methane gas production could be achieved as more than 30,000 m^3 with a net energy of about 11 megawatt by grinded KW addition in the influent flow. However, about one third less daily methane gas and net energy generations were calculated without KW integration. On the other hand, with the OFMSW feeding to the co-digester with PS, a substantial portion of the energy consumption of WWTPs could be covered by the improvement in biomethane recovery.

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Tyrosol β-rutinoside prepared by transrutinosylation using *Fagopyrum tataricum* seed meal

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Abstract:

Plant biomass is an important source of enzymes, as well as compounds interesting for bioconversion. Enzymatic synthesis using diglycosidases offers effective, environmentally friendly procedures and convenient strategies in preparation of structured oligoglycosides. Seeds of tartary buckwheat (*Fagopyrum tataricum*) possess high rutinosidase activity, being therefore able to transfer the whole rutinosyl moiety from the donor to an acceptor in one step, while containing up to 2.4 % of rutin. Tyrosol, occuring as a component of olive oil waste, is a valuable phenolic compound with broad spectrum of biological activities. Glycosylation of this type of compounds can be benefitial for bioavailability as well as bioactivity of hydrophobic phenolics.
Tyrosol rutinoside was synthesised for the first time with rutinosidase of this origin. This compound has been previously synthetised in our laboratory with rutinosidase from *Sophora japonica* and preparation of a mixture of hardly separatable tyrosol rutinoside regioisomers using rutinosidase from *Aspergillus niger* has been reported in the literature. Synthesis with tartary buckwheat was preoptimized in terms of pH, added rutin, tyrosol and amount of catalyst in the form of defatted seed meal using HPLC analysis. The preparative reaction was then carried out under following conditions: pH 6.5, 33 mM rutin, 72 mM tyrosol and catalyst in amount 3% (w/vol.). The maximal conversion of tyrosol rutinoside achieved more than 61 % (respective to rutin) and the isolated yield 35 % with purity ca. 97 %. Isolation was achieved with combination of chromatographic separation on Al_2O_3, Diaion HP 20 and silica gel. The rutinosylation proceeds regioselectively and results in formation of only one product rutinosylated on the primary hydroxyl of tyrosol (as confirmed by NMR).

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Short biography: Member of the Laboratory of Biocatalysis and Organic synthesis. Working on new methods of valorization of biomass as sources of substances for synthesis of marketable products or bio-based pharmaceuticals. Using perspective enzymes (mainly glycosidases) occurring in plant biomass for biocatalytic synthesis of glycophenolics with pharmaceutical applications. Isolation of specific oligosaccharides from raw plant materials as substrates for transglycosylation or possible industrial applications.

Valorization of agri-based feedstock for organic acids production: biological treatment through two-phase anaerobic digestion

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Abstract:

The use of agro-industrial waste residues as feedstock for biorefinery processes has gained wider attention, being able to generate a substantial amount of valuable products such as fuels, chemicals, energy and by-products. Anaerobic digestion of waste residues and agri-based feedstock is a flexible system, capable of contributing in many integrated pathways i.e. energy production, emission reduction, by-products extraction. Some of the output streams are, indeed, biogas, biomethane, biohydrogen, carbon dioxide, organic acids.
Dark fermentation (DF) is a process based on the early stages of anaerobic digestion (hydrolysis, acidogenesis, and acetogenesis), capable of converting biomass into a hydrogen-rich biogas and organic acids. The possibility of coupling DF and methanogenesis sets out the two-phase anaerobic digestion, which can be carried out by means of layout and process modifications even in existing real scale plants, optimizing the use of biomass and operating parameters i.e. pH, organic load, retention time. Biohydrogen production through DF process alone could not be efficient due to low yield. However, the subsequent recovery of organic acids, and their utilization as biomaterials, can add value to the process.
This study wants to explore agri-based feedstock valorization through DF process. The main aim is to compare a “two-phase” to a “single-phase” anaerobic digestion process in terms of operating parameters, performance and, most importantly, in terms of organic acids production in addition to biogas. The experimental continuous tests trials were carried out in 24 liters lab-scale reactors investigating the following conditions:
a) two-phase AD with an acidogenic reactor (R1) + methanogenic reactor (R2)
b) single-phase AD with a control reactor (R3).

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Short biography: She achieved her Master Degree in Industrial Biotechnology at University of Bologna in March 2019. She carried out research activities in Italy and abroad regarding the improvement of the anaerobic digestion process, at Centro de Engenharia Biológica (Portugal) and on the recovery of added value compounds from food by-products at Instituto de la Grasa (Spain). She started her activity at CRPA in September 2019 as biological assistant for biogas plants; her research topics are focused on the optimization of the anaerobic digestion process, biomass pre-treatment technologies, waste treatment processes, integrated biorefineries, and sustainability of the biogas and biomethane supply chain.

Production of optically pure lactic acid from waste wood via continuous fermentation with cell-recycle

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Abstract:

The biotechnological production of lactic acid (LA) is currently based on raw materials such as corn, cane sugar or cassava. To overcome the competition with food production, the testing of alternative raw materials is of high interest. Attention is directed to lignocellulosic substrates (LCS), which occur in the form of residual and waste materials of various industries. In the project "Acid-based hydrolysis of untreated waste wood recyclates for the provision of biochemicals" (HyAlt4Chem), L-(+)-LA was successfully produced from waste wood hydrolysate by continuous fermentation with cell-recycle and full downstream of the gained fermentation broth, employing thermophilic *Bacillus coagulans*.

Within the project, various waste wood hydrolysates were tested for fermentation. LCS are challenging materials for microorganisms, since they contain varying mixtures of hexose and pentose sugars that can be unsuitable for metabolization. Additionally, the pretreatment of LCS often leads to the formation of growth inhibitor compounds, e.g. hydroxymethylfurfural and furfural. Thermophilic *B. coagulans* strains isolated by the ATB from various natural resources are promising candidates for the work with LCS. Some advantages that distinguish them from other LA producing microorganisms are:

- Homofermentative production of LA avoids the formation of by-products
- Hexose and pentose sugars are utilized concurrently
- High optical purity of over 99.5 % L-(+)-LA
- Growth inhibitor tolerance
- Less contamination problems due to thermophilic nature

Employing *B. coagulans*, waste wood hydrolysate was tested for discontinuous batch mode as well as continuous fermentation with cell-recycle. Within these first trials fermentation duration was limited to 48 h. However, comparative tests with synthetic medium suggested that a process duration of 180 h is possible. From the continuous fermentation of wood hydrolysate, 26.7 L of product stream was gained and purified to highly concentrated L-(+)-LA of >99% optical purity performing various steps of downstream processing.

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Characterization and optimization of an additive-enhanced spent tea waste (STW) biochar for boosting biogas yield in co-digestion process

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Abstract:

This research proposal aims at characterizing and examining the impact of a high-quality biochar derived from valorizing the spent tea waste (STW) and co-digestion of different substrates (Spent Coffee Grounds (SCG)/Orange Waste Ground (ORG)/Peanut Shell Ground (PSG)) on the biogas yield. The high-quality biochar will be synthesized by pyrolyzing the STW and modifying its properties through the application of some treatment processes. The high-quality biochar will be used as an additive during the anaerobic co-digestion of various combinations of SCG, ORG, and PSG as substrates for enhancing the biogas yield. This work is currently ongoing study under TWAS-TUBITAK (2216/B) POSTGRADUATE AND POSTDOCTORAL FELLOWSHIP PROGRAMMES. With this, this research proposal falls very well with the TWAS-TUBITAK program in that its contribution will be directed toward achieving global environmental goals such as proper waste recycling and mitigating the greenhouse gas (GHGs) emissions. Additionally, this work will contribute to the Turkish national energy supply by utilizing the country's readily available organic wastes for energy production. It will further contribute to the advancement of waste-to-energy utilization as a field of interest in the global energy supply chain. The project also is interesting to the stakeholders involved in the green energy industry. The project also offers an excellent opportunity for the scientific collaborations between the researchers in Nigeria and Türkiye. The project involves active researchers from both countries with excellent research and publications records.

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Short biography: Dr. Kemal Koca received his B.S. degree in Mechanical Engineering from Yıldız Technical University in 2012 while his M.S. and Ph.D. degrees were received Energy Systems Engineering from Erciyes University in 2016 and 2022, respectively. His main areas of expertise are waste to energy and renewable energies. He was accepted from Bundeswehr University and Technical University of Munich (TUM) during his Ph.D. period thanks to scholarship ensured by TUBITAK. After graduation from Ph.D., Dr. Koca joined to Mechanical Engineering, Renewable Energy Department of Abdullah Gül University (AGU) in 2022 as an assistant professor. So far, he has published 20 papers in international peer-reviewed journals. His h-index values are 11, 11 and 10 on Google Scholar, Scopus and Web of Science (WoS), respectively. Furthermore, he currently acts with different tasks in European Cooperation in Science and Technology (COST).

High-rate biogas production from an integrated microbial electrolysis cell and anaerobic digestion system at short hydraulic retention times

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Abstract:

The Microbial Electrolysis Cell (MEC) was proposed as an alternative and sustainable technique for processing waste streams and obtaining hydrogen, methane, and other valuable molecules from organic sources. Research shows that MECs are more efficient at producing methane and removing organic matter than traditional anaerobic digestion (AD). In order to address the drawbacks of anaerobic digestion, including unstable processes, inadequate treatment, low-rate methane generation, long hydraulic retention time (HRT), and so forth, combined/integrated MEC+AD systems have been created. The objective of this study was to increase the biogas production in a combined MEC+AD reactor running at short HRTs with cattle manure as the substrate. The MEC+AD and control reactors were operated in semi-continuous mode by feeding with manure at fixed volatile solid content (3 % VS, 4.15 % TS, 30 g VS/L) and at HRTs from 6 days to 1 day in descending order. The VS feeding corresponded to OLRs from 5 to 30 g VS/L/d. Meanwhile, MEC+AD reactors were supplied with external voltages of 0.3, 0.6, and 1.0 V during the study.

The results showed that biogas production increased consistently in MEC+AD reactors from the lowest OLR of 5 g VS/L/d to the highest OLR of 30 g VS/L/d. Biogas productions in MEC+AD reactors changed between 1.23 L/L/d (HRT: 6 days, OLR: 5 g VS/L/d, 0.3 V) and 5.11 L/L/d (HRT: 2 days, OLR: 30 g VS/L/d, 1.0 V) depending on the HRT and OLR. The methane yields of the MEC+AD reactors changed between 0.09 and 0.24 L CH4/g VS, decreasing with the increase in OLR. The highest methane yield of 0.24 L CH4/g VS was obtained at OLR and HRT of 5 g VS/L/d and 6 days, respectively, in MEC+AD with a supplied voltage of 0.6 V. The methane content of the biogas produced from MEC+AD reactors was in the range of 75–80% at all operational conditions. The methane content of the biogas was independent of the input voltage and applied HRTs, in this study. Input voltages of 0.6 and 1.0 V were significantly effective on biogas production at higher OLRs. During the study, biogas productions and methane yields of MEC+AD reactors were superior to those of the control reactor at all HRTs (6, 4, and 3 days). Energy assessments of the reactors showed that the $(MEC+AD)_{0.3V}$ reactor exhibited the highest energy efficiency according to energy input and output. The energy content of the methane obtained from $(MEC+AD)_{0.3V}$ reactor was 200 times the energy supplied to the reactor. The highest COD, TS, and VS removal efficiencies obtained in MEC+AD reactors were observed at an HRT of 6 days and an OLR of 5 g VS/L/d. The highest removal efficiencies were between 41.4 and 44.9% for COD, 26.1 and 29.5% for TS, and 34.3 and 37.7% for VS, respectively. Current productions in

MEC+AD reactors strictly depended on the applied voltage. The currents obtained from the reactors varied between 8–12, 15–25, and 40–60 mA/L at applied voltages of 0.3, 0.6, and 1.0 V, respectively. The coulombic efficiencies of the MEC+AD reactors changed between 1 and 3%, which needs to be increased by using more conductive electrode materials.

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Short biography: He earned a BSc in Environmental Engineering from Yildiz Technical University/İstanbul (2005), followed by dual MSc degrees in Environmental Engineering from Hacettepe University (2013) and Chemical Engineering from İstanbul Technical University (2018). In 2021, he completed his PhD in Environmental Engineering at Hacettepe University. His research interests include bioenergy production from waste using anaerobic digestion and bioelectrochemical systems. He has explored CO_2 utilization in MECs and phototrophic purple bacteria technologies. With two years of experience as an environmental co-expert in the Ministry of Environment, he currently works as an engineer at the General Directorate of State Airports Authority. He aspires to be a postdoctoral fellow in a foreign university while pursuing sustainable advancements.

Oxidation of a sustainable aviation fuel in vitiated air conditions

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Abstract:

Sustainable Aviation Fuels (SAF) can be derived from a variety of sources such as coal, oil shale, plants and animal fats. The compositions of alternative jet fuels can vary significantly based on the feedstocks and production processes and can be different compared to conventional jet fuels. Therefore, to achieve a sustainable and green aviation through SAF, understanding their fundamental oxidation properties is essential to guarantee the development of aircraft engines and the improvement of aeronautical propulsion systems, in particular for non-conventional applications, like vitiated air-conditions (i.e. afterburner chamber conditions). Indeed, the presence of non-negligible concentrations of CO_2 and H_2O in the combustion chamber can affect the combustion properties, as largely demonstrated in literature for the oxidation of other fuels. However, few studies have been carried out to date to investigate the effects of vitiated air on aviation fuels. Given this framework, the oxidation of a SAF was investigated through experimental tests in a Jet Stirred Flow Reactor (JSFR) as a function of the inlet temperature, at fixed dilution level (in N_2 and N_2-CO_2 as diluent species), residence time and equivalence ratio, at nearly-atmospheric pressure. Simulations were carried out with the Perfectly Stirred Reactor code of CHEMKIN PRO using a detailed kinetic mechanism in order to further study the effect of H_2O on the SAF reactivity and speciation. In addition, some simulations were performed considering both CO_2 and H_2O, assuming a CO_2/H_2O ratio typical of the complete combustion of the stoichiometric SAF/air mixture. Moreover, the ignition delay time for diluted and vitiated conditions was numerically analyzed to emphasize the effect of H_2O and CO_2 on the reactivity of the mixture. A five-components fuel surrogate was identified for the numerical investigations, based on the chemical analysis on the SAF and literature study.
The experimental results suggested that CO_2 can affect the oxidation behavior of the fuel. In particular, due to its high specific heat capacity, it reduces the maximum temperature increment of the system. In general, CO_2 has a delaying impact on the oxidation process, thus a higher inlet temperature is required to ignite the mixture.
At T<1000 K, the unburnt species formation is slightly affected by CO_2, while for higher temperatures the mixture with 50% CO_2 oxidizes with the highest CO formation whereas the mixture with 70% CO_2 produces the lowest concentrations of H_2 and CO.
Numerical results showed that H_2O has a slightly promoting effect on mixture reactivity for T<1050K, while it retards the oxidation process for higher temperatures. This effect is emphasized for high concentrations of H_2O in the dilution (H_2O>20%). The impact of vitiated air conditions on the ignition delay time is consistent with the previous findings. As a matter of fact, compared to

N_2 dilution, CO_2 increases the ignition delay time within the entire temperature range, while in case of H_2O dilution, the ignition delay time is lower for T<1000K and increases for higher temperatures.
Such behaviors have to be correlated to both thermal and kinetic effects.

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PM emissions from biomass conversion

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Abstract:

Despite the effort done for several decades, at present only simplified interpretations of aerosol formation in thermochemical biomass conversion are available. There is a lot to be done towards detailed understanding of these phenomena. The present work aimed at summarising recent case studies, elaborated at TCS, aiming to experimentally measure pollutants (primary gaseous and particulate matter - PM), emitted during biomass thermal conversion. The experiments were carried out under well controlled laboratory conditions. In focus were the kinetic parameters, determining the process of biomass and/or solid biofuels conversion as well as the pollutants, formed while utilizing lignocellulosic biomass or solid biofuels that are currently being available at the Bulgarian energy market. The size-segregated PMs (from 16 nm to 10 microns), emitted from various types of solid biofuels, were experimentally measured using spectrometric and gravimetric analytical methods. When possible, the PM was characterized through chemical and/or physical methods. In most cases, the fraction of the so called ultrafine particulates ($PM_{\leq 1}$) was the dominant over the course particulates and those particulates were found to contain above 80 % of carbon, which was attributed mainly to the content of tar and soot. Comparing the PMs, measured in the flue gases of fuel-particle and char-particle (from one and the same type of solid biofuel), the results showed that PM concentration tends to zero during char-particle combustion. These experiments confirmed the hypothesis that the formation of organic aerosols (merely the so called ultrafine particulates) is determined by the mass fraction of volatile organic compounds in the initial biomass/biofuel. Such results are of significant importance for the current air quality standards, relaying on the concept for “cleaner combustion” when biomass is utilised instead of coal.

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Characteristics of ammonia/methane MILD Combustion in a cyclonic burner

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Abstract:

In the energy transition scenario, ammonia is considered a valuable energy carrier, due to its very high hydrogen-density and infrastructures for its production. Despite such advantages, its combustion features (narrow flammability limits, high fuel-NOx emissions, high auto-ignition temperature,) may hinder its wide utilization. In order to overcome such issues, “fuel enhancers” are also used. Differently from traditional systems, MILD Combustion already demonstrated to be very effective in converting efficiently ammonia in terms of stability and NOx emission. Nevertheless, a more reactive fuel can be also useful in MILD Combustion conditions to further improve the oxidation characteristics. The present study focuses on the ammonia/methane combustion characteristics under MILD Combustion conditions in a lab-scale burner. Gaseous pollutant emissions and process stability limits were analysed as a function of the equivalence ratio and blending ratio. Results showed that the use of NH3/CH4 blends extends the stable operational range of the system, in terms of both working temperatures and equivalence ratios, with respect to pure ammonia. On the other hand, blends produce higher NOx emissions, with respect to both the pure ammonia and methane cases. Experimental data were compared with chemical kinetics modelling results. Chemical pathways and rate of production of main intermediate products highlighted that oxidation pathways of carbon and nitrogen-based species are essentially decoupled as experiments suggested. In contrast, the interplay of the methane and ammonia main chemical pathways affects the DeNOx channel in correspondence of the observed NOx emission increase.

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Enhancing oxygen reduction via N-doped graphene derived from PET bottle waste as an efficient carbon support for PdNi nanoparticles

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Abstract:

The finite reserves of fossil fuels and the environmental pollution caused by their excessive use for energy production are critical problems for the world. Therefore, it is urgent to seek for cleaner energy sources. Fuel cells (FCs) directly convert chemical energy from environmentally friendly compounds into electricity, and are attracting attention from researchers as sustainable power sources. FCs are advantageous in several aspects as they enable using low-cost non-noble metals in the electrocatalysts, thus reducing the amount of noble metals.
This work aims to design efficient and inexpensive nanostructured catalysts for oxygen reduction reaction (ORR), the cathodic reaction of most fuel cells. The electrocatalyst support is essential for reducing the amount of noble metal. Additionally, it should be made from low-cost materials, if possible, from waste. The prepared samples were synthesized from polyethylene terephthalate (PET) plastic water bottle wastes by pyrolyzing them with urea and Ni metal. The final powder product was collected and finely ground. PdNi@NG catalysts with three Pd metal loading ratios 5, 10, and 15 wt.% (noted as PdNi_5@NG, PdNi_10@NG, PdNi_15@NG) were then obtained by gently mixing Ni@NG powder and chloro palladium solution into a beaker for 1h. Then, 1 mL of a 1M $NaBH_4$/1M NaOH solution was added and gently stirred for 24 hours. The resulting catalyst was dried for 12 hours at 60 °C after being filtered and thoroughly rinsed with deionized water until no chloride was detected. Detailed physicochemical analysis of the newly prepared catalysts was investigated via ICP-OES, XRD, XPS, SEM-EDS, TEM, N_2-sorption analysis, FTIR, and Raman spectroscopy. The electrocatalytic activity of the prepared catalysts was evaluated towards ORR by cyclic voltammetry and linear scan voltammetry in an alkaline solution (0.1 M KOH) in the potential range from -0.8 V to 0.2 V (vs. SCE). The studies showed that the prepared PdNi@NG catalysts have high electrochemical activity for ORR, together with good stability in an alkaline media. The PdNi_15@NG catalyst exhibited the best electrocatalytic activity for ORR. N-doped graphene from PET bottles waste was demonstrated to be an effective electrocatalyst support for ORR electrocatalysis.

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Short biography:
Dr. Aldona Balčiūnaitė is a Senior Research Associate at the Center for Physical Sciences and Technology. In 2017 she defended her doctoral dissertation “New materials for alkaline fuel cells: synthesis, characterization, and properties”. Her main research areas include fuel cells, catalysts, electroless metal deposition, and electrochemical methods of analysis. Her research area is related to promising, worldwide intensive research into the properties of materials used in fuel cells. It is focused on the search for new efficient materials that can be applied in direct alkaline fuel cells to enhance the performance of existing or new fuel cells.

Potential of biomass pyrolysis products in MILD combustion

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Abstract:

In the fast evolving concept of smart energy grid, the integration of alternative and renewable energy sources is mandatory. However, many of them suffer intermittency and seasonality limitations. In this respect, the chemical storage of renewable energies to produce both conventional and innovative energy carriers is one of the most attracting solutions. In particular, these energy vectors include many fuels, among which bio- or thermochemical conversion of biomass unquestionably occupies a relevant role, with the aim of maximizing the sources renewability and the storage capacity of renewable energy. However, due to the high content of diluting species, which varies case by case and depends on the conversion process from biomass and on the biomass itself, the direct utilization of these low-grade fuels requires the development of combustion technologies able to ensure fuel flexibility and high combustion efficiency. In this respect, MILD Combustion [1] is one of the most attractive, suitable for the direct conversion of low calorific value fuel deriving from degradation of biomass. With this background, in this work combustion performances of several model gas surrogates were experimentally investigated in a cyclonic flow burner under MILD combustion conditions. Three different fuel mixtures were identified as gaseous fraction of biomass pyrolysis products, obtained from different feedstocks and in different conditions, covering a wide range in terms of mixture composition, diluting species content and heating value. Operative temperatures, combustion stability and pollutant emissions were monitored with respect to operative conditions (mixture composition, equivalence ratio, preheating level and thermal power). Experimental results showed that, as long as operative temperatures are higher than the classical crossover temperature (1100 K) [2], the oxidation process can be stabilized in a wide range of equivalence ratios by means of an effective preheating strategy. With respect to the speciation, both the mixture composition and considered operational parameters slightly affect NO_x emissions, that always keep lower than 10 ppm, whereas CO emissions depend on both CO-CO_2 ratio in the fuel mixture. In particular, lower CO emissions have been detected for the fuel mixture with the lowest %CO_2, despite the highest inlet CO content. This behavior is due to the slightly higher operative temperatures detected for the identified case, since the higher heating value of the fuel mixture, that boost the CO conversion to CO_2.

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References
[1] Sabia, P., Sorrentino, G., Ariemma, G. B., Manna, M. V., Ragucci, R., & de Joannon, M. (2021). MILD combustion and biofuels: A minireview. Energy & Fuels, 35(24), 19901-19919.
[2] De Joannon M., Cavaliere A., Donnarumma R., & Ragucci, R. (2002). Dependence of autoignition delay on oxygen concentration in mild combustion of high molecular weight paraffin. Proc Combust Inst, 29(1), 1139-1146.

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Fate of lead during pyrolisis of lignocellulosic biomass

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Abstract:

In recent years, lignocellulosic biomass role as an alternative energy source to fossil fuels gain interest among the scientific community. Both its direct use and, even more, the use of biofuels produced after upgrading chemical and thermo-chemical processes, among which the pyrolysis, have been analyzed in the scientific literature and demonstrated in selected cases. To address the rising demand for lignocellulosic biomass, required to this aim, while mitigating iLUC (indirect land use change) related concerns, a viable solution could be the use of biomasses produced on marginal lands and contaminated soils. However, the biomasses produced on contaminated soils may be as a consequence contaminated by pollutants contained in the soils, like heavy metals (HMs). The presence of heavy metals in the biomass structure could hinder both its processing through pyrolysis and the subsequent use of the potentially contaminated pyrolysis products.
In the above-mentioned framework, the aim of this work is to evaluate the fate of lead (Pb) during contaminated lignocellulosic biomass pyrolysis in terms of lead distribution between pyrolysis products; moreover, it has to be considered that the presence of HMs can also modify the yields and properties of pyrolysis products. The experimental campaign tested a variety of combinations of pyrolysis final temperatures (from 450 up to 800 °C) and biomass pretreatments (i.e. untreated or doped with HMs salts). The employed biomass is a poplar (*Populus nigra*); the poplar biomass was doped via wet impregnation with two different lead salts, lead acetate and lead nitrate, to achieve a concentration of lead of 1000 ppm. Moreover, by using two different salts, information can be gained on the effect of the starting chemical form of lead on its fate during pyrolysis. All the pyrolysis products, as well as the untreated and doped biomass, were characterized in their yields and composition. In particular, the ICP-MS (Induced Coupled Plasma Mass spectroscopy) represents a key tool for the purpose of this work, since it detects HMs in the biomass and pyrolysis products at ppm levels, granting the possibility to track lead displacement during pyrolysis.
In summary, the present work aims to shed light on the basics of heavy metals behaviors during the pyrolysis of HMs contaminated lignocellulosic biomass. Moreover, the possible effects of HMs on pyrolysis products yield and properties are also analyzed.

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Performance of an auger reactor for bio-oil production through fast pyrolysis of contaminated biomass

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Abstract:

CERESiS (ContaminatEd land Remediation through Energy crops for Soil improvement to liquid biofuel Strategies) project, granted under EU Horizon2020 research and innovation programme, intends to promote land decontamination through phytoremediation by growing energy crops to produce clean biofuels. In this context, the project aims to demonstrate the potential of two thermochemical processes, i.e. Supercritical Water Gasification (SCWG) and Fast Pyrolysis (FP) for the production of key bio-fuel precursors suitable for further upgrading from contaminated biomass.
The aim of our research activity is to design a FP system which allows to obtain at the same time high yields and low levels of contaminants in the bio-oil.
The auger reactor configuration was chosen. The advantages of using an auger reactor are summarized as follows:

- Proven technology.
- Wide range of particle sizes that can be processed.
- Good control of residence time and temperature.
- Good mixing characteristics.

In contrast, the main disadvantage is the high cost of maintenance required, given the presence of moving parts and possible tar condensation on the shaft when an auger reactor heated only indirectly through the external wall is used. To deal with tar condensation problems the reactor is heated by three independent induction heaters that allow reaching high heating rates of the shaft with great efficiency. A two-stages fractionated condenser, a cyclone and an electrostatic precipitator are used to selectively capture solids and condensable products.
The auger reactor was designed to valorize contaminated biomass coming from phytoremediation adapting the plant and operational parameters to the presence of inorganic contaminants. Both pelletized and ground contaminated biomass can be used as feedstock for bio-oil production. Further investigations are needed to assess the possible effect of feedstock size on pyrolysis products yields and heavy metals speciation and distribution.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).
The work has received financial support through the project CERESiS - ContaminatEd land remediation through energy crops for soil improvement to liquid biofuel strategies, funded through HORIZON2020 (Project No 101006717).

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Short biography**:** I'm a PhD student and I'm studying fast pyrolysis for bio-oil production. My work focuses on heavy metals contaminated biomass valorisation through fast pyrolysis. The main aim of my PhD thesis is to identify the transformations that heavy metals undergo during pyrolysis and to identify the optimal operating conditions that allow obtaining good-quality bio-oil with a high yield starting from contaminated biomass. I started working on waste biomass valorisation during my master's degree thesis, when I studied the feasibility of the extraction of bio-active molecules (i.e. polyphenols) from a specific biomass, and their recovery and concentration by sorption on biochar produced from the same biomass.

Novel membrane pervaporation processes for separation and purification applications in modern biorefineries

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Abstract:

The concept of biorefineries is a green approach of biomass conversion to valuable products that can smoothly replace fossil oil refineries, in which multiple fuels, chemicals, and other by-products are produced from petroleum oil. In modern biorefineries, the efficient production of biofuel from waste materials involves a series of steps, i.e. pre-treatment of waste, processing and synthesis of biofuel and finally purification. However, conventional downstream purification processes, are energy intensive and costly. Such drawbacks can be overcome by advanced membrane-based separation and purification technologies.

Pervaporation is a membrane separation technology which can be used as potential alternative to state of the art energy-intensive separation processes such as distillation. The separation principle in distillation is based on the vapour-liquid equilibrium, whereas separation in pervaporation is based on differences in components' solubility and diffusivity through the membrane. The separation mechanism in pervaporation allows the separation of certain mixtures which cannot be separated by conventional distillation. Generally, pervaporation can find applications in separating azeotropic or close-boiling mixtures and volatile organic compounds, as well as in removing trace concentration components. Moreover, pervaporation processes operate continuously (except of the applications when/where a periodic membrane cleaning is necessary), having a completely modular design that allows an easy and flexible scale-up. All these perfectly fit to the current trends in process design and render pervaporation technology very attractive, either as standalone or as hybrid separation process.

In the current presentation potential application fields of the membrane pervaporation technology in modern biorefineries (e.g. in liquid biofuels dehydration, transesterification reactions, etc.) will be discussed and analyzed.

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Short biography: Dr. Dimitris Koutsonikolas holds a diploma and a PhD in Chemical Engineering from Aristotle University of Thessaloniki. He works as Research Engineer in National and EU funded research projects since 2004. He has participated in more than 10 European projects as member of the research team, in 5 as PI and in 1 as project coordinator. His main field of expertise is on membrane separation technologies. He is the author or co-author in >25 articles in peer reviewed journals and/or books and he is also co-inventor in a European patent relevant to membrane technology.

Biorefinery upcycling of agri/food byproducts into compound biofertilizers and bioenergy in a scale of circular economy viability and applications with market competitive reproducibility

Edward Someus

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Abstract:

The EU fragile agri-food markets already seriously affected by external factors such as global warming, pollution, loss of fertile soils/biodiversity. The COVID-19/war in Ukraine together are putting EU agriculture under extreme pressure with significantly increased energy/fertiliser costs for long term. Due to the high dependence on imports of energy/fertilisers the agri-food sector became significantly vulnerable. Therefore the replacement of the non-renewable, energy demanding made and imported chemosynthetic mineral fertilizers into bio based fertilizes needed. One of the most important crucial and complex challenge is the replacement of the cadmium/uranium contaminated and imported CRM Critical Raw Material phosphate (P)rock/mineral phosphate and substitute with high nutrient dense, high quality/safe and EU origin P bio-fertilizers. In this context, need to urgently build large scale EU capacity in full value chain under market competitive conditions for recovered and EU origin secured P-supply from secondary raw materials. For achieving resilient EU agriculture need to rapidly/EU scale replace the inappropriate toxic mineral fertilisers to novel bio-based fertilisers and reduce the EU import dependency on mineral fertilisers including replacement of the Russian origin.

The interdisciplinary/circular-economical solution is the unique 3R (Recycle-Recover-Reuse) zero-emission/energy independent innovative upcycling process with revolutionary industrial design/know-how, which has been expressively developed for safe/efficient animal by-product processing to user create values/benefits. This consists of two steps:

1.) high temperature pyrolysis of renewable/unexploited biomass food grade animal bone meals to recover high phosphorus content animal bone char (BioPhosphate) under zero emission conditions and absence of air. All material streams upcycled, reused and converted into useful safe products. The BioPhosphate is made of food grade cattle and other types of bone meal from the rendering industries. The material is heated to as high as 850ºC material core carbonization temperature, which is far higher than usual biochar pyrolysis processing temperatures up to 450ºC material core, but in the animal by-product cases it is absolute needed to get high quality and safe product. Auto-thermal, no external energy is needed, surplus green energy produced.

2.) Biotechnological formulation of the BioPhosphate for production of BIO-NPK-C compound biofertilizer to full value replace the non-renewable CRM and chemically processed mineral fertilisers. Bio-Phosphate comes in 100% from a sustainable and renewable by-product stream that is unexploited biomass that is made of food grade category 3 animal bones. This unique

macro porous material having low carbon content and as high as economical 35 %-P2O5 nutrient density composition with plant uptake optimized controlled release fertilization effect. As the material nutrient density is exceptional high, the fully safe ABC is used at economically low doses, such as 200-500-kg/ha and in cases when justified even up to 1,000-kg/ha. The solution is less costly than the mineral fertilisers under market competitive conditions. The formulated BioPhosphate is increasing soil health/biodiversity, safe, sustainable, resilient and long term (beyond 2030) adaptive to all EU climatic/soil conditions as of new EU Reg. 2019/1009/European Green Deal and other incentives. In next TRL9/CRL9 full industrial and commercial replication model implementation targeted in scale of economy 20,800t/y capacity for EU/global market replications.

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Short biography: Swedish upcycling engineer, specialized for circular economical carbon refinery and valorisation of unexploited agri/food industrial by-products/waste. Education: University of Lund in Sweden 1972-1978. Core competent in zero emission/energy independent novel high temperature pyrolysis (3R), syngas bioenergetic processing and biotech formulation of biochar products. Specialized for Phosphorus/Nitrogen nutrient recycling, recovery and reuse to create values and market competitive benefits for users by application of innovative BIO-NPK-C compound biofertilizer products. EU regulation expert. Coordinator and key technology designer for several large scale EU science/technology RTD programmes since 2002 aiming conversion of science into full industrial practice towards TRL9 with market competitive reproducibility.
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Prospective Life Cycle Assessment of microbial sophorolipid fermentation

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Abstract:

Refinery industry is transitioning from fossil and chemical-based processes to more sustainable practices emphasizing renewable resources. Sophorolipids, a promising group of biosurfactants, present a viable substitute for conventionally produced surfactants. This study focuses on life cycle assessment (LCA) of the microbial sophorolipid fermentation. The fermentation was done in a 5L lab-scale bioreactor, using yeast *Starmerella bombicola* (DSM 27465 strain), and raw rapeseed oil as a lipid substrate. Prospective LCA methodology was employed to identify environmental hotspots of the process. The hotspots that had a significant environmental impact (>1%) were addressed. The identified hotspots were electricity consumption (85.1%) and lipid source in fermentation substrate, namely raw rapeseed oil (14.2%). In terms of damage categories, the LCA results showed that human health is significantly impacted by electricity consumption due to the release of particulate matter during the combustion of solid biofuels in power plants. Meanwhile, ecosystems receive most of the damage from the use of raw rapeseed oil through land use change, agricultural practices, and potential chemical inputs, affecting biodiversity, soil health, and water resources. The environmental impact of the production can be reduced through optimization. This can include selecting a different substrate, improving technologies, and adjusting growth parameters to reduce electricity consumption. In this study, we proposed and assessed alternative scenarios to minimize the impact, such as using waste cooking oil instead of raw rapeseed oil, energy saving measures, and maximised use of bioreactor working volume. To reduce electricity consumption (kWh per 1 kg of produced sophorolipids), we considered shortening the fermentation process, utilizing the maximum working volume of a lab-scale bioreactor chamber, and increasing energy efficiency of the process by measures such as lower temperature, reduced mixing speed or reduced heat loss from the process. LCA results showed that longer fermentation time resulted in 150% higher environmental impact, as the experimentally obtained sophorolipid titre was lower. Utilizing the maximum working volume of the bioreactor reduces the environmental impact by nearly 5%. Meanwhile, increased energy efficiency by 5%, 10% and 15% yielded reduction in environmental impact by 4%, 7% and 11%, respectively. Using waste cooking oil as the lipid source helps avoiding the environmental impact caused by raw rapeseed oil and allows achieving a 28% reduction in environmental impact of the fermentation process assuming that the sophorolipid titre is the same as for the base scenario, i.e., 196.3 g/L. If higher sophorolipid titre is achieved, as was demonstrated in our laboratory experiments, then the impact can be reduced by as much as 52%. We assessed a hypothetical scenario that compiled the most environmentally favourable strategies. Specifically, achieving a

50% higher titre using waste cooking oil combined with maximised use of bioreactor working volume and a 15% reduction in electricity consumption would potentially lead to a 60% reduction of the environmental impact compared to the base scenario. This research provides valuable insights into environmental optimization of fermentation. Through LCA application, it highlights potential reductions in the negative environmental impact of sophorolipid production.

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Integration of multi-products from bay tree pruning waste biorefinery into bioactive food packaging absorbent pads

Esther Rincón, **Eduardo Espinosa, María Pinillos, Luis Serrano**

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Abstract:

Food waste is a reality with major implications not only ethical and economic but also environmental since we are in an environment of limited natural resources. One of the factors in the supply chain with the greatest effect on food waste is the processing and packaging stage. Packaging not only protects the food but also enhances its quality. Therefore, it is key to work on this stage. Moreover, in this environment of fossil resource depletion, a shift from plastic-based packaging to sustainable packaging is imminent. The enormous potential already shown by agricultural and agri-food waste to be valorized in the context of biorefinery and to obtain useful fractions finds application in the development of bio-based packaging. The present work focuses on the development of bioactive absorbent pads for the preservation of packaged meat by incorporating in their formulation several fractions of agricultural by-products. The fractionation of bay tree pruning waste has been carried out to obtain lignin-containing or lignin-free cellulose micro/nanofibers and, on the other hand, bioactive bay leaf extracts. In a first stage of the study, the formulation of these absorbent pads in aerogel format has been optimized using chitosan as biopolymeric matrix and being reinforced with increasing amounts of the cellulose micro/nanofibers, also studying the effect of the presence/absence of residual lignin. The results showed that the presence of cellulose micro/nanofibers improves the mechanical performance of the aerogels (more than 60%) in addition to increasing the water absorption capacity (42%) when lignin is present. The optimum reinforcement formulation of aerogels was found to be 5% cellulose micro/nanofibers. The second stage of the study involved the incorporation of bioactive bay leaf extract at various increasing concentrations (0.3-20%) into the optimized aerogels. The bioactive aerogels showed high antioxidant capacity. The residual lignin present in the micro/nanofibers was decisive as the release profiles of the extract were faster, reaching more than 85% antioxidant power in only 30 min. Finally, these bioactive aerogels were used as absorbent pads in fresh meat during 10 days of storage. The use of these pads made it possible to obtain fresh meat after storage, delaying the oxidation of the food (20% proportion of metmyoglobin).

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Short biography: Postdoctoral researcher at University of Cordoba (Spain). My research focuses on the valorization of various agricultural and agri-food wastes from the point of view of multi-product biorefinery to obtain products and materials with high added-value in various industrial applications. The focus of the research is on both the optimization of biorefinery processes for the purification of the different fractions (cellulose/nanocellulose, lignin, hemicelluloses and bioactive polyphenols) and their final application. The main application of these fractions so far has been the development of sustainable active food packaging. However, I am exploring new application routes such as the development of functional hydrogels for 3D bioprinting.

Lignin nanoparticles with entrapped *Thymus spp.* essential oils for the control of wood-rot fungi

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Abstract:

After decades of utilization of fossil-based and environmentally hazardous compounds for wood preservation against fungal attack, there is a strong need to substitute those compounds with bio-based and circular solutions, such as bioactive essential oils and renewable and abundantly available lignin, which often derives from waste biomass. In this work, lignin nanoparticles containing essential oils from different thyme species were applied as biocide delivery systems in in vitro experiments to test their anti-fungal effect against two white-rot fungi (*Trametes versicolor* and *Pleurotus ostreatus*) and two brown-rot fungi (*Poria monticola* and *Gloeophyllum trabeum*). Entrapment of essential oils in a lignin carrier matrix provided a delayed release over a time frame of 7 days and resulted in lower minimum inhibitory concentrations of the essential oils against the brown-rot fungi (0.30–0.60 mg/mL), while for the white-rot fungi, identical concentrations were determined compared with free essential oils (0.05–0.30 mg/mL). Fourier Transform infrared (FTIR) spectroscopy was used to assess the fungal cell wall changes in the presence of the lignin nanoparticles loaded with essential oils in the growth medium. The results regarding brown-rot fungi present a promising approach for a more effective and sustainable utilization of essential oils against this class of wood-rot fungi when being applied in a lignin-based delivery system.

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Short biography: Florian Zikeli has been working with lignocellulosics since his PhD thesis in 2010, which he conducted both at TU Wien and KTH Stockholm. He was working especially with lignin isolation and characterization using NMR spectroscopy, UV spectroscopy, molar mass analysis via HPSEC, and wet chemistry methods. From 2017, he has worked as a Post-Doc in Italy, University of Tuscia in Viterbo, studying lignin nanoparticles for wood-related applications such as biocide delivery systems or surface treatments. From 2020, he was a research assistant at TU Wien for almost two years, before he went back to University of Tuscia to start in a researcher position.

Exploring sustainable asphalt binders: insights into the effects of char chemico-physical characteristics

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Abstract:

Nano-sized particles, thanks to their high surface-to-volume ratio and tuneable chemical composition, are emerging as new additives for asphalt binder preparation since they can exert a significant effect on the rheological properties of bitumens and asphalts, even when added in very small percentages. In particular, it has been demonstrated that fine particles are able to increase the load capacity of the pavement and decrease the formation of cracks due to fatigue during the pavement's operation life. Carbonaceous particles thanks to their chemical compatibility with the bitumen (they are both carbon-rich materials) are candidate of choice for this kind of application. In particular, the use of char as a bitumen modifier has been tested by different authors and in all the cases, improved mechanical performances were detected. The relationship between chemico-physical characteristics of char and the effect on bituminous preparations is a key state-of art issue and is under a growing interest. In this work, char samples differing in composition and structure have been produced and tested as additives in asphalt binder preparations. The following feedstocks have been selected and pyrolized up to 550°C under nitrogen atmosphere: alkali lignin to produce a high aromatic char; chitosan, *Posidonia oceanica* (commonly known as Neptune grass or Mediterranean tapeweed) and thistle (*Cirsium vulgare*) to produce N-rich char types; lemon peel and pectin to produce O-rich char types. All these char samples, after a deep chemico-physical characterization have been used as additives in asphalt binder preparation. After the standard rheological characterization, to test the effect of chars also as anti-aging additive, the bituminous preparations were subjected to an artificial aging process (RTFOT process) and the resulting mechanical properties evaluated.

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Short biography: Valentina Gargiulo holds a Master's degree (2005) and a Ph.D. (2009) in chemistry from the University Federico II, Naples, Italy. In July 2020, she obtained a position as a researcher at the Italian Research Council (CNR), and since October 2020, she has been a member of the STEMS-CNR permanent staff. Her research activities deal with the synthesis and characterization of advanced materials, the characterization and treatment of pyrolysis feedstocks and products, and the chemico-physical analysis of complex carbonaceous materials.

Effect of catalyst acidity and reduction step on carbon dioxide valorization

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Abstract:

Over the last decades, carbon dioxide (CO_2) is incessantly accumulated in the atmosphere due to human activities, especially in countries with developed economies. CO_2 constitutes one of the main greenhouse gases and CO_2 emissions are linked with global warming and several environmental concerns, thus strategies and technologies for the immediate mitigation of CO_2 emissions should be adapted as critical. CO_2 valorization techniques have been developed, using CO_2 as feedstock for the production of high added value products (chemicals and/or fuels) by heterogeneous catalysts with multifunctional structures. Heterogeneous Catalysis employing proper multifunctional catalysts has attracted great attention by the global scientific community. Within this context, mixed metal-based oxides were synthesized in order to catalyze the Reverse Water-Shift (RWGS) reaction (CO_2 is converted into CO), as well as Fischer – Tropsch (FTS) like reactions (CO hydrogenation). Alkali promoters were added to enhance selectivity into olefins, while the synthesized oxides were dispersed on acidic supports that promote deoxygenation reactions. Preliminary experiments were conducted to elucidate the effect of the reduction of the metal oxides and the zeolitic acidity/SAR on materials' catalytic performance. Samples were reduced for four hours prior to RWGS resulting in the production of C1-C3 deoxygenated species, such as methane, ethane, propene and propane. Further reduction did not improve CO_2 conversion and selective product distribution. Overall, reduced alkali promoted magnetite nanoparticles dispersed on H-ZSM5 (140-160 SAR) showed the most promising results with 9.3% CO_2 conversion, as well as 16.4 and 81.1% selectivity to CO and methane, accordingly.

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Pyrolysis atmosphere effect on biochar properties and PTEs behavior

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Abstract:

Pyrolysis is considered as a prospective safe treatment for biomasses contaminated by potentially toxic elements (PTEs). The PTEs speciation and their chemical transformation during the thermal treatment result in significantly different volatility of the PTEs. Previous study revealed that, in presence of one or more PTEs among Pb, Cu, and Zn, it is possible to pyrolyze contaminated biomasses up to 600°C retaining PTEs in the biochar attaining a final product characterized by low metals mobility and high porosity (1). These two characteristics, high surface area and PTEs stability, suggest the opportunity to evaluate the valorization of biochar in different application fields (fertilizer, activated carbons precursor, filler in wood and polymer composites, contaminants adsorbent in wastewater and soil, floating cover) (2, 3).
Nevertheless, it is worth to underline that few studies exist dealing with the PTEs behaviour as a function of pyrolysis temperature for different biomass types. Whereas, the influence of pyrolysis atmosphere on the biochar properties is often overlooked. To the best of our knowledge, there is still a comprehension gap concerning the PTEs fate, as well as mobility in the biochar produced under different pyrolysis atmospheres. To this aim, in the present study the effect of the carrier gas composition on both physico-chemical properties of biochar and PTEs fate during pyrolysis has been experimentally investigated. Slow pyrolysis experiments of Pb contaminated Populus nigra (Pb = 21.65 mg kg^{-1}) were conducted using N_2, CO_2, steam and a mixture of them as carrier gas at different temperatures (465°C, 550°C, 700°C). Products yield, gas composition and biochar chemical and physical characteristics were measured, and Pb recovery in the biochar was determined. The chemical forms of heavy metals were analysed in accordance with the sequential extraction method proposed by the Community Bureau of Reference (BCR). The preliminary results show that the nature of the carrier gas influences pyrolysis products yield and Pb recovery in the biochar as well as its mobility.

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PTEs Closed-loop: from biochar production via pyrolysis of contaminated biomass to its applications in soil bio-remediation

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Abstract:

Recently, there has been increasing interest in understanding biochar as a whole, particularly for its prospects and applications and its multidisciplinary role in agricultural and environmental sustainability development. Biochar applications showed beneficial effects on soil structure, pH, soil organic carbon content and stability, and, therefore, soil fertility. It also revealed as a promising sorbent for the remediation of contaminated water and soil. However, the chemistry behind biochar behaviour for the remediation of heavy metal contaminated soil is still ongoing. Additionally, there is still a lot of room for improvement in developing of biochar applications obtained from pyrolysis of contaminated biomasses. Biochar physical-chemical properties and yields are influenced by the feedstock composition, but also by the operating pyrolysis parameters (temperature, residence time, heating rate, and reaction environment). Moreover, as demonstrated in previous studies in presence of potentially toxic elements (PTEs) the type of plant and pyrolysis temperature have an important impact on PTEs behaviour and recovery in the biochar. The confinement of PTEs in the biochar has also the advantage of producing a pyrolysis condensable fraction suitable to be used as biofuel. However, each PTEs is characterized by different thermal behaviour and fate, as well as by a distinct mobility and bioavailability in the biochar. Previous studies showed that PTEs (Zn, Cd, Cu and Pb) were more easily leached under acidic conditions from the raw biomass rather than the respective biochar produced at 480 °C. Thus, for a safe use of a PTEs enriched biochar an ecological risks assessment is fundamental before and after biochar is applied to soil. To this aim, in the present study contaminated biomass of Populus nigra (Pb= 21.65 mg kg-1; Cd= 8.15 mg kg-1) used for phytoremediation was treated under slow pyrolysis condition (10 °C/min) in inert environment (N2= 12 slm) up to T= 465°C. Based on previous results this is a critical pyrolysis temperature for Cd and Pb recovery in the biochar, pH and specific surface area suitable for biochar applications in the soil. Biochar chemical and physical characterization and analysis to evaluate potential environmental risk (toxicity characteristic leaching procedure, TCLP) of biochar derived from contaminated P. nigra was assessed. Finally, the biochar produced, when applied at 3 % rate, reduced the concentration of labile (i.e. water soluble and exchangeable) Cd, Pb and Zn present in a contaminated mining soil from Sardinia (Italy) by approx. 25, 33 and 50 % respectively.

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Short biography: Corinna Maria Grottola is a scientist at STEMS-CNR. She is an environmental engineer with a Ph.D. in industrial product and process engineering (University Federico II, Naples, Italy). Her scientific expertise covers thermochemical conversion processes of lignocellulosic contaminated biomasses. Her research is focused on the characterization of the slow pyrolysis process through physical−chemical (porosity, gas chromatography) and optical analyses (infrared laser based) of the products, with peculiar attention to char valorization as a bioproduct, and to the fate of heavy metals during the pyrolysis of contaminated biomasses.

Technical and market challenges in the chemical recycling of mixed wastes

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Abstract:

The selection of the appropriate technologies for plastic wastes conversion to energy and materials and for the use of the products is a rather complex task, especially when dealing with mixed non-recyclable plastic with organic waste.

- What type of commercial technology, pyrolysis, gasification, or others in development?
- Will it be suitable for all types of wastes including composites and containing chlorine, brome, or other contaminants?
- How constant is the waste source, and how to handle it?
- What are the nature, quantities, and composition of the products- gaseous, liquid, solid – and how to valorize them efficiently and in accordance with the local laws?
- How to proceed with the construction of a pilot plant?

The paper or poster will provide feedback about the experience of a pilot plant project in Switzerland, carried out by three major companies: a large recycling company, a power production and distribution company a pyrolysis plant manufacturer, and a purchasing and logistics platform for energy companies. A first phase, aiming at the selection of the right technologies to handle a variety of unrecyclable plastic wastes, has already been carried out. It included extensive pyrolysis tests on two lab scale prototypes and a life-cycle comparison of different valorization pathways for the pyrolysis products: incineration, combined heating and power or transport [1]. The second phase is on-going and aims at the demonstration of a 1600 tons/year pyrolysis pilot plant, to transform various types of wastes, including cable insulation materials and food packaging into liquid and gaseous fuels. The pilot plant components are currently being built and the plant should be operational towards the end of 2024. All the above-mentioned challenges have been addressed with various possible solutions, with a final choice that is yet to be evaluated.

[1] J.B. Michel et al. (2022) Detailed evaluation of technologies for the pilot scale pyrolysis of plastic wastes. Paper presented to 13th European Conference on Industrial Furnaces and Boilers.

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Short biography: Jean-Bernard Michel, Ph.D in Energy technologies (Valenciennes, 1983), linkedin.com/in/jbmichel1 After a rich R&D career in several internationally renowned laboratories in the Netherlands and Switzerland (IFRF, Battelle, CSEM), and as professor, he now acts as trainer for Cenertec in Portugal and consultant and trainer, Solar Impulse Expert for the World Alliance for Efficient Solutions at Solar Impulse Foundation and Advisory Board Member at Race for Water Foundation. He is a MC member of the WIRE COST action.

Valorization of CO_2 through dry reforming of CH_4: Design of Ni/La_2O_3 catalysts as a function of the preparation method.

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Abstract:

Global warming is an urgent and critical environmental concern driven by escalating carbon dioxide (CO_2) emissions, primarily originating from the combustion of fossil fuels. To mitigate this issue, dry reforming of methane (DRM) has emerged as a viable approach, producing syngas (H2/CO) crucial for synthetic fuel generation, and contributing to greenhouse gas reduction. However, DRM presents significant challenges due to its highly endothermic nature and concurrent side reactions, such as methane decomposition, Boudouard reaction, and CO reduction, leading to catalyst deactivation via carbon deposition [1]. Consequently, only a limited number of industrial-scale plants currently employ DRM as their primary process. Among the catalysts used, Ni supported catalysts are prevalent due to their cost-effectiveness and wide availability. Nevertheless, these Ni catalysts are susceptible to sintering at elevated temperatures and coke deposition, necessitating improved support characteristics, such as enhanced metal particle dispersion, increased basic properties, and augmented surface oxygen species availability [2,3]. Hence, tailored catalysts and specific supports play a crucial role in addressing these issues. Recent research has demonstrated that the performance of Ni-based catalysts in DRM can be significantly enhanced through the incorporation of promoters, optimization of synthesis conditions, and modification of support materials [4-6]. By employing suitable support oxides and promoters, the dispersion of Ni particles can be improved, carbon deposition can be controlled, and the redox properties of the catalyst can be enhanced, resulting in heightened catalytic activity and selectivity towards syngas production [1-6]. These findings present valuable insights for developing novel, efficient, and stable catalysts for CO_2 conversion via dry reforming, offering a promising avenue to address the dual challenges of energy production and environmental sustainability.This study aims to present advancements in the design of new Ni/La_2O_3 catalysts for CO_2 reforming of CH_4, contributing to the development of more effective and sustainable DRM processes. The research focuses on the effect of different preparation methods on the catalyst activity and stability.

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investimento 3.5 “ricerca e sviluppo sull'idrogeno" – AdP ENEA-CNR (CUP B93C22000630006) are also acknowledged.

References

[1] Lanthanoid-containing Ni-based catalysts for dry reforming of methane: A review (**2022**), M.A. Salaev, L.F. Liotta O.V. Vodyankina, International Journal of Hydrogen Energy, 47 (7), pp. 4489-4535.
[2] Ni/La_2O_3 catalysts for dry reforming of methane: Effect of La_2O_3 synthesis conditions on the structural properties and catalytic performances, M. Grabchenko, G. Pantaleo, F. Puleo, O. Vodyankina, L.F. Liotta, International Journal of Hydrogen Energy 46 **(2021)** 7939-7953.
[3] Design of Ni-based catalysts supported over binary La-Ce oxides: Influence of La/Ce ratio on the catalytic performances in DRM, M. Grabchenko, G. Pantaleo, F. Puleo, T.S. Kharlamova, V.I. Zaikovskiim O. Vodyankina, L.F. Liotta, Catalysis Today 382 **(2021)** 71–81.
[4] Strong impact of indium promoter on Ni/Al_2O_3 and Ni/CeO_2-Al_2O_3 catalysts used in dry reforming of methane, A. Horvath, M. Nemeth, A. Beck, B. Maroti, G. Safran, G. Pantaleo, L.F. Liotta, A.M. Venezia, V. La Parola, Applied Catalysis A, General 621 (**2021)** 118174
[5] CO_2 reforming of CH_4 over Ni supported on SiO_2 modified by TiO_2 and ZrO_2: Effect of the support synthesis procedure, V. La Parola, L.F. Liotta, G. Pantaleo, M.L. Testa, A.M. Venezia, Applied Catalysis A, General 642 **(2022)** 118704.
[6] Gold and Ceria Modified NiAl Hydrotalcite Materials as Catalyst Precursors for Dry Reforming of Methane, V. La Parola, G. Pantaleo, L.F. Liotta, A.M. Venezia, M. Gabrovska, D. Nikolova, T. Tabakova, Catalysts **2023**, 13, 606.

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Can oil and char from waste pyrolysis be used as eco-binders to improve asphalt durability? A challenge from a circular economy perspective

Michela Alfè[1], Valentina Gargiulo[1], Giovanna Ruoppolo[1], Paolino Caputo[2], Abraham A. Abe[2], Michele Porto[2], Valeria Loise[2], Pietro Calandra[3] and Cesare Oliviero Rossi[2]

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Abstract:

Recently, much attention has been paid to the research and the development of alternative eco-binders to totally or partially substitute bitumen in asphalt production as well as in the discovery of new potential anti-oxidant agents to be added in bituminous mixtures to reduce susceptibility to oxidative aging and thereby extend the life of asphalt pavements. In this framework, the present study aims to investigate the potentiality of products from waste pyrolysis to act as alternative binders or additives in asphalt preparation with the ultimate goals of effective resource use, recovery and recycling, non-renewable resource conservation, reduction of production costs and achievement of a regenerative circular economy. In particular, char and oil deriving from the pyrolysis of civil wastes (scraped tires, WT) and refused derived fuel, RDF) have been considered as new-concept alternative binders and additives for asphalt preparation. After a deeper chemical and structural characterization, the oil samples (WT-oil and RDF-oil) have been tested as new eco-binder, fluxing and rejuvenation agents while the two char samples (WT-char and RDF-char) have been tested as additives in asphalt binder preparation. To test anti-aging effects, the bituminous mixtures containing the pyrolysis products as additives were subjected to an artificial ageing process (RTFOT process). These preliminary tests revealed differences in the effect of the two pyrolysis products. Specifically, the WT-char can exert an anti-aging by reducing the increase in rigidity typically observed after aging. On the other hand, the pyrolysis oil can be used both as fluxing and as rejuvenation agents.

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Utilization of fast pyrolysis bio-oil for wood modification

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Abstract:

The Thermo Chemical Fractionation (TCF) technology has been developed to utilize low-value resources to produce a broad range of bio-based chemicals. This process converts biomass residues by fast pyrolysis into Fast Pyrolysis Bio-Oil (FPBO), a liquid product that contains chemicals derived from the depolymerization of chemical constituents of biomass. Subsequently, the FPBO is fractionated based on chemical functionality-yielding into a reactive lignin fraction and a sugar-rich fraction, both being excellent starting materials to produce sustainable, bio-based chemicals. This research focuses on the modification of wood with FPBO to develop an entirely biobased alternative to currently used toxic and fossil-based preservation agents such as copper salts, organic biocide ingredients and creosote.
Ten formulations based on FPBO were prepared and characterized in terms of pot life, viscosity, and curing behaviour among others. The impregnation process of radiata pine samples was performed in the bench-scale reactor. The uptake of the impregnation liquor was assessed by calculation of weight percent gain (WPG) for each specimen. Penetration depth was assessed with hyperspectral imaging. Characterization methods included moisture uptake, dimensional stability, density, mechanical strength, UV stability, durability tests against fungi and moulds, fixation of components, and VOCs emission. The characterization campaign aims to select 3-4 best-performing treatments and prepare a set of experimental samples, that will be evaluated regarding their performance in outdoor applications. After extensive laboratory tests, new construction products will be manufactured at an industrial scale and used at a demonstration site. The performance of the materials, moisture content, and temperature in envelope layers will be monitored in situ, allowing for observing the deterioration of materials and estimating service life regarding functionality and aesthetics. This information will be used for future optimization of the formulation and modification process as well as the scheduling of recommended maintenance actions.

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Short biography: I am associate Researcher at InnoRenew CoE in the Materials group and Asst. Prof. at the University of Primorska, Slovenia. Currently, I am working as Marie Skłodowska-Curie Postdoctoral researcher (MULTI-WOOD project), focusing on innovative strategies to improve critical wood properties. My academic background includes a master's degree and a PhD in renewable materials engineering from the Chemical and Environmental Engineering Department at the University of the Basque Country (Spain).

Production and recovery of biochar for agricultural use, gas cleaning and wastewater treatment

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Abstract:

Biochar is a by-product from thermochemical processes, namely pyrolysis, torrefaction or thermal gasification, where conversion takes place in a sub-stoichiometric environment and with high carbon content, nutrients with ammonia, high cation exchange capacity, large surface area and stability structure. Different raw materials grant different properties to biochars, thus presenting different performances. When biochars are produced at high temperatures, through thermochemical processes such as thermal gasification, it is possible to observe a higher surface area and higher carbon content. These factors are mainly associated with the increase in the volume of macropores from the removal of volatile organic compounds at high temperature, however the yield is lower with higher temperatures. Biochar has pores ranging from micro to nano, with biochars with small pore sizes being obtained from thermochemical process or milling. Adsorption is one of the mechanisms of biochars for the reduction of heavy metals and organic pollutants. Being directly linked to the physicochemical properties, such as surface area, pore size distribution, functional groups and cationic capacity, these being dependent on the conditions of obtaining the biochar. To improve the physicochemical properties of biochars from different processes, modifications with acids, alkali, oxidising agents and metal ions are applied as a way to vary the surface area. The versatility of biochar to interact with organic and inorganic species is related to its porosity and the presence of surface functional groups. This interaction can be enhanced through activation processes, improving the biochar's absorption capacity. The use of biochar in soils can be considered as an alternative for carbon sequestration and consequently a way to mitigate climate change. By incorporating biochar into soils, it is possible to verify long-term persistence, associated with an increase in pH, cation exchange capacity, specific surface area and abundant surface functional groups. Currently, there is great interest in the production of biochar due to its energy storage capability and possible use as anodes, gas, wastewater cleaning, and biofuels. Lately biochars are of great interest due to their properties and have emerged as attractive adsorbents, mainly due to their low production cost. Due to its property as a carbonaceous material, it has exceptional properties for the removal of pollutants from aqueous solutions, namely wastewater. The hydrophobic nature of biochars is an important factor for the adsorption efficiency of dissolved organic material fractions that are mostly present in effluents from water treatment plants and landfill leachates. Biochars can also be used for the removal of emerging contaminants such as endocrine disrupting chemicals found in wastewater and for the removal of herbicides found in water from crop pest control applications, among other contaminants found in effluents. The use of biochars, in addition to helping to reduce the amount

of greenhouse gas emissions, can also contribute to achieving the United Nations Sustainable Development Goals.

Details of presenting author

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Short biography: Roberta Mota Panizio has a degree in Environmental Engineering (UTFPR, Brazil), a master's degree in Technologies for Environmental Enhancement and Energy Production (IPPortalegre, Portugal), a PhD in Bioenergy (FCT-UNL, Portugal). She is a senior technician at IPPortalegre's Technology and an integrated researcher at VALORIZA (Research Center for Endogenous Resource Valorization). Her main interests are related to the energy recovery of waste, thermochemical processes, biological processes and the production of renewable gases (hydrogen and methane). She has published more than 90 papers in scientific journals, book chapters, conference proceedings, posters. (https://orcid.org/0000-0001-5408-6071)

Fueling a sustainable tomorrow: Harnessing biomass for a prosperous and greener future

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Abstract:

The environment is known to have an elephantine memory, retaining all our actions through time, the right and wrong ones. For a sustainable future, the new and forthcoming generations of engineers must understand that their choices can trigger a chain reaction of consequences that ultimately shape the long-term sustainability of our planet. Known as the butterfly effect, within the context of sustainability, this concept refers to the idea that small actions or changes, seemingly insignificant at first, can have far-reaching and significant impacts on the environment, ecosystems, and overall sustainability over time. This concept is derived from chaos theory and illustrates how complex systems like the environment are interconnected and sensitive to initial conditions.

Over the last years, we have been introduced to longtermism. Despite the longtermism controversies, those advocating it believe that it is the responsibility of those living in the present to ensure that future generations will have the means to survive and prosper. And the truth is that we have never witnessed such urgency in taking immediate measures to safeguard the planet's livability for future generations. Consequently, in 2015, the United Nations established the 17 Sustainable Development Goals (SDG), a blueprint for achieving a better and more sustainable future for all. Sustainable Development can be defined as the development that allows us to evolve without compromising future generations to meet their needs. Biomass and its derivatives can play a significant role in assisting in achieving some SDGs. Biomass, residues, and derivatives can be converted into sustainable added-value chemicals and energy carriers as alternatives to fossil sources. The visions for a sustainable future and their evolution through the history of humankind will be presented. Examples of how biomass can be used to ensure the planet's livability, not only for the present generation but for the upcoming ones, will be presented and discussed.

Details of presenting author

Name: **Rui Galhano dos Santos**
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Short biography: Rui Galhano dos Santos got his PhD in Organic Chemistry in 2013 from the University of Lisbon, after having completed his degree in Chemistry in 2006 at the Faculty of Sciences of the University of Lisbon. He is a senior researcher at Instituto Superior Técnico. He frequently lectures at Instituto Superior Técnico and Instituto Superior de Engenharia de Lisboa. He has published more than 30 articles in scientific journals and is co-inventor in 9 patents. Presently, his studies are mainly focused and involves the studies and development of new strategies to up-cycle biomass and wastes for the production of added-valuable chemicals and/or materials as well as for the productions of bio-fuels. Besides his exceptional knowledge of biomass liquefaction, organic synthesis, and carbohydrate chemistry, he has a scientific background in polymer chemistry, extraction, and separation of natural compounds, chemical structure elucidation, 1D and 2D-NMR, green chemistry, scale-up of chemical processes, biorefineries. In early 2016, Rui Galhano dos Santos became a permanent member of CERENA - Center for Natural Resources and Environment.

Utilizing renewable hydrogen in industrial heating: A sustainable solution

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Abstract:

The industrial sector is a significant contributor to global carbon emissions due to its extensive reliance on fossil fuels for heating processes. To combat climate change and transition towards cleaner energy sources, the exploration of alternative fuels becomes imperative. This abstract highlights the promising role of renewable hydrogen as a sustainable solution for industrial heating applications. Renewable hydrogen is produced through the process of water electrolysis, powered by renewable energy sources such as wind, solar, or hydropower. This production method offers a carbon-neutral alternative to traditional hydrogen production methods, which often rely on fossil fuels. In industrial heating, renewable hydrogen can be used as a clean and efficient energy carrier. Its high energy density and clean combustion properties make it a viable option for various heating processes, including industrial furnaces, kilns, and boilers. By integrating renewable hydrogen into industrial heating systems, companies can significantly reduce their carbon footprint while ensuring process efficiency and reliability. This abstract discusses the advantages of using renewable hydrogen, including its environmental benefits, potential cost savings over time, and its compatibility with existing infrastructure. Additionally, it explores the challenges and opportunities associated with the adoption of renewable hydrogen in industrial settings, such as the need for efficient storage and distribution solutions. The utilization of renewable hydrogen in industrial heating presents a compelling opportunity to decarbonize a critical sector of the economy. As global efforts to combat climate change intensify, the integration of renewable hydrogen into industrial processes represents a forward-looking strategy that aligns with sustainability goals and the transition towards a greener, low-carbon future.

Details of presenting author

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Short biography: Dr. Sven Eckart is a mechanical engineer with a strong background in combustion technology. He obtained his Bachelor's and Master's degrees in Mechanical Engineering from the TU Dresden and TU Bergakademie Freiberg, respectively, between the years 2008 and 2015. Since April 2015, Sven has been working as a research assistant at the Chair of Gas and Heat Technology at the TU Bergakademie Freiberg. From 2016 to 2019, Sven was awarded an ESF-PhD scholarship by the state of Saxony and the European Union. In February 2022, Sven successfully completed his Doctorate in Dr.-Ing. with a thesis titled "Investigation of the relationship between the hydrogen content in natural gas and the pollutant emissions during technical combustion."

Waste biorefinery technologies for accelerating sustainable energy processes

Fueling change: Analyzing new car sales and policy impact in the pursuit of environmental sustainability

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Abstract:

In an era of rapid transition from internal combustion engines to electric vehicles, a comprehensive understanding of the factors influencing new car sales is critical. Global initiatives to decrease carbon emissions, such as the European Union's 2035 ban on combustion-engine cars, pose complex challenges to policymakers striving to balance environmental sustainability, market demands, and societal well-being. This research explores the complex interaction between economic, technological, environmental, and societal factors affecting new car sales. It aims to develop public policies and tools that encourage cleaner energy adoption while maximizing social welfare. Through a nuanced yet accessible analysis, the model offers a robust framework to evaluate the impact of various policy instruments, including emission fees, subsidies, and the electric car infrastructure. The model further elucidates the welfare implications of biofuel bans and limitations on biofuel production. Utilizing an economic approach and technical considerations, this study offers a strategic roadmap for policymakers, stakeholders, and the automotive industry to navigate the evolving landscape of transportation toward a greener future.

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Short biography: Tunç Durmaz is an Associate Professor in the Economics Department at Yildiz Technical University in Istanbul, with research interests spanning climate change, energy economics, green growth, and prosumer behavior. His work has appeared in prestigious journals like Energy Economics, Renewable and Sustainable Energy Reviews, and Economics Of Energy & Environmental Policy. At Yildiz Technical University, he teaches courses in Microeconomics, Environmental Economics, and Energy and Resource Economics, among others. Durmaz holds a Ph.D. in Economics from the Norwegian School of Economics, where he explored the role of technology in promoting green economic growth and the economics of electricity storage.

RePower - Connecting between famers and industry for a higher energy production

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Abstract:

Globally, 69% of farmers lack the knowledge and resources to properly manage their agriculture waste. On the other hand, companies that can treat and convert this waste into energy struggle to connect with farmers, leading to increased investments in selling departments. This situation creates two significant considerations; first, waste treatment costs are high and, secondly, most of the waste is treated throughout processes that are not the most appropriate, leading to low energy production. A platform (phone app and computer software) was developed that promotes the most adequate treatment for the farmer waste at the lowest price. The farmer adds to the App crop data, such as kind, growth area size, growth process and localization (through GPS). The app sends the data to the computer software, where it is analysed and the waste amount, due production and best treatment process is determined. Moreover, the software takes in consideration mixing of different wastes that are present in the same neighbourhood, for a higher energy production with lower costs for the farmers. The software further sends the results of the analysis to waste treatment industries that can best convert the waste into energy. These industries send back to the software prices and conditions for the waste treatment. The farmer can choose the best option for himself: price vs. conditions. The whole process can help farmers and industries, reducing costs and increasing energy production; with the added benefit of reduction in carbon emissions and joining the mission of the Paris Climate Agreement for reducing global warming by 2050.

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Short biography (Prof. Beni Lew's field of research is in ‘processes and systems for agricultural wastes treatment, being granted with several international prizes for his research and teaching skills. Prof. Lew published more than 50 international papers and books at high Impact Factor journals, participated in several international conferences and; has been invited to lecture at different countries (Brazil, Greece, USA, Poland and India). Prof. Lew had PhD students and Post-Doc come from different parts of the world (Germany, Italy, India, Brazil and USA) in his lab and part of these students are nowadays professors in their own countries.

The science of communicating science - Disseminating facts, not fiction

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Abstract:

Science communication encompasses all aspects of communicating scientific work and scientific outcomes, both within science and in the interaction between science and the public. The recent COVID-19 crisis has brought to light the urgent need to improve public understanding of the scientific process in all areas of knowledge. This understanding includes concepts that are obvious to the scientific community but need to be broadly disseminated, such as the time needed between fundamental discoveries and their application, and the development of scientific knowledge through questioning, revisiting and self-correcting acquired knowledge.
Current trends in science communication point towards a two-way process: a dialogue between the different target groups and the research community. This approach requires a more transparent and collaborative science, and more participation of citizens, through cooperation between different actors or stakeholders, including individuals and organizations, who can contribute or benefit from research, regardless of whether they are researchers or not.
This work is included in WIRE's WG4 – Communication & Dissemination and aims to describe and discuss the status of science communication, particularly in the fields of biorefineries, biomass, and wastes. These areas are common targets of misconception, which need to be cleared out using novel communication tools and a closer relation with stakeholders and overall target audiences. New forms of science communication, such as social media and more participative methods like debates, science cafés, festivals, researchers' nights, will be addressed, to understand how their use can add value to spread the benefits and correct facts about waste biorefineries.

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Short biography: Bruna Rijo has a PhD in Chemical Engineering (IST - University of Lisbon) and works on waste valorization using thermochemical processes. She is currently a researcher at CoLAB BIOREF where research activities are mostly focused on technologies for Bioenergy and Renewable Gases. As a result of her research activities, she has contributed to more than 30 publications, including peer-reviewed scientific papers, posters and oral communications.

Unveiling innovation pathways in biorefinery technologies: A comprehensive patent landscape study

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Abstract:

The global shift towards sustainable and renewable energy sources has spurred intensive research and innovation in the field of biorefinery technologies. This abstract presents an overview of patent data analysis focused on biorefinery methods and processes, highlighting key trends, innovative concepts, and interdisciplinary approaches in biomass conversion. The dataset comprises patents and patent applications from diverse jurisdictions, underscoring the global significance of biorefinery research. The temporal distribution of publication dates indicates a sustained interest in this field, with origins dating back to 2004. Patent types include both granted patents and applications, reflecting the recognition of inventive solutions by patent offices. Analysis of the abstracts reveals a spectrum of pioneering ideas in biorefinery research. These range from novel methods for producing petrochemical products from biomass to advanced processes utilizing high shear and cavitation. Notably, innovations extend to the efficient conversion of macroalgae, C1 substrates, and wastewater into biofuels and valuable chemicals. The diversity of technologies encompassed in the dataset underscores the interdisciplinary nature of biorefinery research. Hydrodeoxygenation, catalytic conversion, and energy-efficient drying are just a few examples of the multifaceted approaches taken to optimize the biomass conversion process. Importantly, a considerable number of patents address environmental concerns, presenting inventive strategies for minimizing carbon emissions and remediating toxins. Resource efficiency emerges as a common theme, exemplified by patents that leverage biomass processing residues and wastewater to obtain hydrogen for oil hydrogenation. These strategies not only contribute to the circular economy but also align with the overarching goal of sustainable resource utilization. The dataset's representation of various applicants and assignees, including energy companies and academic institutions, underscores the collaborative nature of biorefinery research. This collaborative effort between academia and industry indicates a shared commitment to advancing sustainable biorefinery technologies. In conclusion, the patent data analysis provides a comprehensive glimpse into the dynamic landscape of biorefinery technologies. With a focus on innovation, sustainability, and interdisciplinary collaboration, these advancements hold promise for transforming biomass into high-value products while addressing global challenges in energy, waste reduction, and environmental impact.

Details of presenting author

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Short biography: He is an assistant professor at the Department of Energy Systems Engineering at NEU. After obtaining B.Sc. degree in Chemistry at Bilkent University, he was awarded European Erasmus Mundus Scholarship for both his M.Sc. & Ph.D. in Materials for Energy Storage and Conversion (MESC) and Sustainable and Industrial Chemistry (SINCHEM), respectively. He has been involved in several national/international projects and various COST Actions. His research interests mainly cover materials for energy storage materials, lignocellulosic biomass valorization, catalysis, and IPRs. As a Qualified Patent Attorney since 2013, he is also in charge of European Patent Office PATLIB 2.0 Centre in Konya.

Commissioning of a 1 barrel per day Fischer-Tropsch slurry bubble column reactor

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Abstract:

A bio-based economy is only possible if the best fitting conversion technologies are selected which are different at each occasion based on feedstocks, markets and regularities. Fischer-Tropsch synthesis (FTS) is a long and well-known conversion technology which enables the production of a variety of hydrocarbon-based products from synthesis gas CO & H_2. To incorporate it in bioeconomy research must be carried out on the potential of feedstocks and the compatibility of bio-based syngas supply and FTS. Here, the slurry bubble column reactor (SBCR) seems promising as it allows for highly dynamic load changes and high product selectivity.
At BEST Bioenergy and Sustainable Technologies in Vienna a research platform was constructed to investigate the full process chain of biowaste to the final product of hydrocarbons from FTS at a TRL of 6. The goal of this STSM in October 2022 was to assist in the final commissioning of the 1 bpd SBCR reactor in Vienna, Austria under supervision of Gerald Weber and gain knowledge necessary for scale-up of the smaller plants (TRL4) at KIT. Herein, laboratory equipment was tested and calibrated, process safety according to TÜV regulations was improved, the process flow diagram was updated, the reactor was cleaned and filled with wax and catalyst and the start-up of the FT process chain monitored. As a result of the performed work, the entire process chain at BEST from woody biomass to FT product could be operated on 28/10 for the very first time.
The commissioning and sharing knowledge on operation and analytics on the pilot-scale FT-SBCR was successful and can be shared, thus contributing to T2.2. It also marks the first major milestone for FT synthesis pathways in T2.3, especially with more innovative FT operation modes investigated by KIT. During the stay it became evident that together with KIT, the entire research chain for Fischer-Tropsch up to TRL6 can be covered which leads to more and already ongoing joint projects in the future.
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Philipp Graefe was born 1997 in Schwerte and studied Chemical Engineering at TU Dortmund from 2014 until 2020 when he was awarded the M.Sc. degree During his studies, he received numerous grants, e.g. the “Wacker Preis” for the best Bachelor, and took part in exchange programs Sweden Japan. After finishing his Master thesis on “Investigation of Reaction Kinetics and Interfacial Phenomena in Multiphase Catalysis” at the Max-Planck-Institute for chemical energy conversion, Philipp Graefe commenced his PhD studies at Karlsruhe Institute of Technology (KIT) in 2021. There, his research focuses on three-phase CO_2-Fischer-Tropsch synthesis in the frame of the InnoSyn project.

Databases for biomass and waste biorefinery - A mini-review and SWOT analysis

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Abstract:

The world is facing problems of the increasing amount of resources wasted as the world population grows. Biobased waste streams form a significant part of the overall waste generation, and a circular economy utilising this biowaste will significantly reduce waste whilst lowering the anthropogenic carbon footprint. The world currently relies heavily on the non-renewable fossil fuels for the production of chemicals, materials, fuels and energy. This is causing serious problems of global warming and climate change. Thus, it is necessary to substitute fossil fuels with renewable resources such as bio-based waste streams to reduce the carbon footprint and climate change. Due to their energy content and high concentration of hydrocarbon molecules, bio-based waste streams have the potential to be transformed into valorised products (energy, fuels, chemicals and materials) using biorefinery technologies. In this work, a mini-review has been conducted on available databases on existing biomass types and biorefinery technologies to provide a framework for a desirable, comprehensive database connecting bio-based waste streams, biorefinery technologies and bioproducts, as well as the geographical distribution of feedstocks and biorefineries. The database assessment utilised the SWOT (strengths, weakness, opportunities, threats) methodology to support benchmark analysis and to identify critical gaps in underlying data structures that could be included in a single database. The results show that the update frequency of databases and accessibility are key important factors. Current databases are useful but insufficient for waste biorefineries due to limited quality and quantity as well as the usability of data. A comprehensive database or improved database cluster would be necessary, not only for technology development but for better investment and policy decisions.

Keywords: Bioproducts; Biowaste; Circular bio-economy; Biorefinery; Bio-based feedstock; SWOT methodology

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Details of presenting author

Name: **Morgen Mukamwi**
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Short biography: Morgen Mukamwi is a PhD researcher in Chemical and Process Engineering at the University of Strathclyde, United Kingdom. His PhD research seeks valorisation of biomass for sustainable production of hydrogen. The focus of the research is on developing a carbon tolerant, biochar-based catalyst for steam catalytic reforming of syngas hydrocarbons and tar to maximise hydrogen production in biomass gasification. Development of the catalyst involves catalyst design, synthesis, characterization and testing in the reforming environment. The work also involves thermodynamic and catalytic modelling to generate a benchmark for evaluation of catalyst efficiency.

Exploring integrated systems for biorefinery applications: A study of catalytic-chemical processes at KIT-EBI

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Abstract:

It is undeniably the reality of our time that there are numerous decarbonization attempts being undertaken to prevent global warming and its detrimental consequences. This STSM aimed to integrate new perspectives to the Grant Holder's biobased expertise in alignment with the experimental practices of Prof. Rauch's group at the Engler-Bunte Institute (KIT) on chemistry-based technologies. The application of biologically derived products in chemical processes and the comparison of these processes' efficacy will be assessed through the observation of practical applications, and potential partnerships will be established by contributing to the Task 3.1 and Task 3.4 of the CA 20127 WG3 Biorefinery Applications.
Fischer-Tropsch synthesis including the catalytic conversion of gases mainly H_2 and CO, into liquid hydrocarbons can be obtained from renewable resources in order to contribute to the defossilization and conduct a sustainable process (Gruber et al. (2021)). Accordingly, in this study, designated catalysts to capture CO_2 with Fischer-Tropsch kinetic studies is projected. A fully automated lab-scale reactor with a total volume of 500 mL to optimize the independent variables of the process is planned including choice of the catalyst(s). Different process parameters and their cross-influence are projected to be investigated, e.g. temperature, pressure and space velocity to test the performance of the catalyst and gain insights on the final product and application of FT reactions such to give higher activity and selectivity of desired compounds or ability to work in low/high temperatures (Benedetti et al. (2020)). Accordingly, the outcomes of the study may potentially be used to evaluate the use of various waste streams (solid, liquid, or gas) for biological and chemical processes with low or no carbon emissions.

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Biorefinery approach to the valorization of hazelnut shells as a source of antioxidant extracts and biochars.

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Abstract:

Hazelnut shells are important agricultural waste as a biochar. Compared to other organic materials, biochar with high surface area and porosity allows the absorption and retention of water and nutrients. It also creates a habitat for the development of beneficial microorganisms, so it can be considered as a soil conditioner (Glaser et al., 2002; Warnock et al., 2007). In this STSM study, biochar is produced from hazelnut shells. In this study, biocharification of hazelnut shell. It is aimed to determine the most suitable temperature and time parameters values in the process. Biocharring was carried out at a temperature range of 200 °C to 500 °C, with a dwell time of 60 minutes. As a result of this process, hydrophobic, energy density increased, Biochar with high grindability is obtained. The obtained biochar is used together with coal in coal combustion systems or as fuel in gasification systems. Temperature, particle size, residence time, heat flow, biological properties of the used biomass are the parameters that affect the process. The effect of temperature increase on biomass yield was investigated.

Characterization of residues from tannins extraction for a future valorization

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Abstract:

Wood is a precious natural resource that generates a substantial economic market. In 2020, four hundred thousand companies were involved in wood transformation in Europe. This large number of companies generates a significant amount of waste, prompting research to find innovative ways of recovering this waste. Improving the recovery of industrial waste would minimize environmental impacts. One of the value-adding solutions currently in use involves the use of polyphenols, in particular lignin and tannins, in a variety of applications. Tannins in particular are used in pharmaceuticals, cosmetics and as antifungal additives. Tannins can be extracted using a variety of methods, but in all cases generate a by-product that is currently not valorized. The purpose of this work is thus to carry out a complete characterization of these residues to consider potential ways for their valorization. To achieve this, two by-products were analyzed: the first was obtained from the extraction of tannins from maritime pine bark (*Pinus pinaster*), and the second from the extraction of tannins from oak heartwood (*Quercus robur* and *Quercus petraea*). These two by-products were characterized in terms of chemical composition and physical and thermal properties. Maritime pine residue has been demonstrated to have significant hydrophobic properties, due to its high content of suberin. The oak residue exhibited excellent antioxidant properties, better than the commercial antioxidant (BHT), as well as remarkable thermal resistance. With this complete characterization, companies could consider providing added value to their currently under-valued compound. These by-products could also replace synthetic compounds in developing new materials while enhancing their properties according to the characteristics found.

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Short biography**:** I'm a 26-year-old French woman. I'm currently doing a thesis in materials chemistry at the IPREM laboratory in Mont-de-Marsan, in France. The aim of my thesis is to develop a biosourced resin to protect wood and wood composites against various degradation agents such as water, fire, UV and fungi.

Upgrading of hydrothermal liquefaction bio-oils by catalytic hydrotreatment

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Abstract:

Hydrothermal liquefaction (HTL) is a biorefinery application, through which residual biomass is being utilized by the conversion to added-value products, leading to a significant circular economy technology. In this method, sub- or supercritical water conditions (250-550 ºC, 5-25 MPa) are used to induce the macromolecules decomposition and oil compounds formation by repolymerization of unstable fractions. Hydrothermal liquefaction results in four different types of products: a gaseous phase mainly containing of CO_2, a solid phase residue, an aqueous liquid phase consisting of inorganics and the bio-oil, an oily phase which can be used as biofuel, after its relative upgrade. The biofuels developed by HTL process could be a green alternative to conventional fossil fuels, especially with respect to the aviation and shipping sector. As known, biofuels can decrease carbon emissions by 83% compared to fossil fuels. However, the integration of such processes, the implementation and the upscaling require considerable know-how and joint research. The current Short-term Scientific Mission (STSM) focuses on the bio-oils upgrading through hydrotreatment. Bio-oils produced by different feedstock treatment are going to be processed in order to achieve higher fuel-like properties. Both before and after hydrotreatment bio-oils will be characterized in terms of composition (C, H, N) for the properties comparison. Additionally, the Higher Heating Value of the bio-oils is going to be determined. Apart from the scientific part, the STSM aims at a knowledge transfer between two leading European research institutions concerning the Hydrothermal Liquefaction technology applications. Scaling-up of HTL bio-oils upgrade is going to be considered and future potential collaborations and consortiums creations are going to be investigated through networking in the facilities of the hosting institution.

Details of presenting author

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Short biography: I have been working in CERTH since 2019 when I graduated from the Chemical Engineering Department of the Aristotle University of Thessaloniki. I have been involved with the experimental development of hydrothermal liquefaction (HTL) and physicochemical characterization of feedstock and products for more than four years, while I have also contributed to the design and construction of lab and pilot scale HTL units. The research topics and outcomes have been published in peer reviewed journals and presented in international conferences throughout these years. I have participated in proposal preparation groups of CPERI/CERTH and I have experience in managing scientific projects.

Waste biorefinery technologies for accelerating sustainable energy processes

Utilization of lignocellulosic waste for sustainable biofuel production: A comparative process simulation and techno-economic evaluation

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Abstract:

Considering that coffee is the second largest consumed beverage in the world after tea and Norway is ranked second after Finland with an average annual consumption of 8.8 kg per capita, utilization of spent coffee grounds (SCG) on value-added bioproducts are crucial in terms of economic feasibility and environmentally friendly. SCG is one of the significant wastes generated in the entire coffee supply chain from a coffee cherry to a cup of coffee. SCG is generated after the coffee grounds are brewed to prepare coffee. It is mostly disposed of along with municipal solid waste (MSW). This waste powder is a critical feedstock for several value-added products to support the circular economy. Therefore, in this study, SCG is intended to evaluate as a carbon source in biogas and biomethane production. Scope of the study, two different scenarios were proposed and simulated coupled with dark fermentation (DF) & photo fermentation (PF) and dark fermentation (DF) & anaerobic digestion (AD). In order to compare these processes in terms of economic feasibility, the pre-treatment section in the upstream process and plant capacity were kept constant. The principal difference is that hydrogen was the main product in the first scenario through a two-stage process. Yet, hydrogen and methane were produced in the second scenario. Overall, the study was completed by comprehensive comparative economic evaluation and discussed for advantages and disadvantageous. To this end, for validating the economic feasibility of the industrial-scale two-stage SCG processing plants, the techno-economic analysis was undertaken using SuperPro Designer®. Also, some of the fundamental economic notions, such as net present value (NPV), internal rate of return (IRR), and payback period (PB) were calculated.

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Short biography: Dr. Ozturk is working as a Research Associate at the Department of Chemical Engineerin g at Yildiz Technical University. His research interests are biomass valorization, industrial microbiology, solid-state fermentation, process modeling & simulation, biofuel production, and techno-economic evaluation. Until now, believing in the power of international collaboration, he worked as a Visiting Researcher for one month at the National University of Malaysia, one year at the Tokyo Institute of Technology, three months at the Aalto University, about two months at the University of Stavanger and finally approximately one month at the University of Borås.

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