Waste biorefinery technologies for accelerating sustainable energy processes

Book of abstracts

WIRE's 6th Working Groups Workshop

Faculty of Technology Novi Sad, University of Novi Sad

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Foreword

Welcome to the abstract book for the WIRE COST Action 6th Working Groups Workshop, hosted in Novi Sad, Serbia, on October 10-11, 2024. This event gathered 80 participants who presented 40 abstracts in oral presentations and poster sessions. Reflecting our commitment to inclusivity, the workshop had a gender distribution of 54% male and 46% female participants, with young researchers making up 60% of the attendees. Additionally, 82% of participants were from ITC countries, showcasing WIRE COST Action's dedication to fostering diverse, international collaboration.

As we tackle critical global environmental issues, such as rising temperatures and increasing waste, sustainable and innovative solutions have never been more important. Extensive fossil fuel consumption over the last two centuries has significantly raised carbon dioxide emissions, accelerating global warming, while population growth has led to an increase in waste production. Solutions must focus on carbon-neutral energy sources and sustainable fuel production processes. Biorefineries offer a promising pathway by converting biomass and organic waste into useful products, resulting in nearly neutral carbon dioxide emissions compared to fossil fuels. With a shift toward renewable resources, biorefineries play a vital role in helping Europe reach its carbon neutrality goals by 2050.

The recent WIRE COST Action workshop in Novi Sad was instrumental in promoting knowledge transfer and enhancing collaboration between academia and industry. Through these collective efforts, we can develop sustainable solutions that positively impact the environment, economy, and society.

Thank you for your contributions and participation. Together, we are moving closer to a sustainable future.

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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, modeling, 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 & 6th Working Groups Workshop was held in Novi Sad (Serbia) at the Faculty of Technology Novi Sad, University of Novi Sad from 10 to 11 October 2024.

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 & 6th Working Groups Workshop had 60 papers presented as oral and poster communications, divided among the different WGs.

KEYNOTE PRESENTATION

Sustainable Bioprocess Development Through Optimization, Modeling and Simulation

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Abstract:

The development of bioprocesses in a sustainable manner is taking on a global scale in view of current environmental challenges and resource shortages. The integration of biological systems and engineering principles enables the creation of production processes that are in agreement with the concepts of the circular economy. Optimizing the process parameters at the very beginning of the bioprocess development can significantly contribute to the increase in product yield and reduce the amount of secondary products, and thus the generation of waste. Subsequent modeling and simulation of the optimized processes makes it easier for scientists to further examine the observed system through different scenarios, improving the process without unnecessary additional experiments. In this way, the desired goal is achieved, that is, the use of raw materials and waste generation are reduced, and at the same time it contributes to the environmentally safe production of biofuels, pharmaceuticals and other important bioproducts.

Bioprocess optimization is a key segment in the laboratory, i.e., the initial phase of research. Harmonization of process parameters, such as temperature, pH value, aeration and mixing rate, composition of the nutrient medium, bioreactor geometric ratios, etc., with the complex needs of the biological system leads to ecologically responsible and economically reliable production. The possibilities, options and parameters that can be optimized in bioprocesses are numerous, and the application of optimization techniques is important in terms of directing the further flow of research, while reducing the efforts and costs related to them. On the basis of data on optimal conditions, the translation of the examined bioprocess into a larger scale (scale-up) without significant risks is facilitated. By applying various optimization techniques, it ensures the safe development of the bioprocess until commercialization itself.

As an aid to optimization in the development of bioprocesses, modeling and simulation further accelerate the transition from the laboratory, through the pilot, to the industrial phase. By generating models under defined optimal conditions using numerous computer tools, as well as solving those models through simulation, researchers can review and examine different bioprocess options, from the preparation of raw materials or nutrient medium and biological catalyst, through the bioreactor itself as the core of each bioprocess, and up to various bioseparation techniques to obtain the final product. The given models follow the development of the bioprocess from its inception in the laboratory until the industrial plant start-up and validation, supplemented by data that become available as the scale increases. Their application avoids unnecessary consumption of resources for practical testing of different bioprocess scenarios. Finally, the combination of optimization, modeling and simulation techniques contributes to a more effective and accelerated development of the bioprocess, which meets the standards of today's needs in terms of sustainability and circular economy.

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Short biography: Prof. Dr. Damjan Vučurović is an Associate professor in Biotechnology at the Department of Biotechnology, Faculty of Technology Novi Sad, University of Novi Sad in Novi Sad, Serbia. Prof. Dr. Damjan Vučurović participated in several international and national projects and authored three textbooks (Bioprocess Design, Bioprocess Design – handbook and Safety at Work) for students of undergraduate and master study programs in Biotechnology at the Faculty of Technology Novi Sad, and reviews for a dozen of the most prestigious international scientific journals. His research interests mainly focus on biotechnology, bioprocess engineering, bioreactors, bioprocess design, and bioprocess development through optimization, modeling, and simulation. Currently, he is working on developing bioprocess solutions for efficiently utilizing agroindustrial wastes, residues, and by-products for biopolymer production (xanthan, dextran, pullulan), biofuels production (bioethanol), and the production of microbial biomass and bioactive bioproducts (enzymes, biopesticides, probiotics, biofertilizers, biosurfactants). He uses SuperPro Designer, Design Expert, SigmaPlot, and Statistica software packages to model, simulate, and optimize biotechnological processes, define kinetic models, analyze material and energy balances, and perform technical

KEYNOTE PRESENTATION

Sustainable Processing of (Bio)Waste – Thermodynamic Approach

Gorica R. Ivaniš[1], **Ivona R. Radović**[1], **Miha Grilc**[2], **Blaž Likozar**[2], **Mirjana Lj. Kijevčanin**[1]

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Abstract:

The negative environmental and social impacts and the unsustainability of a fossil-based economy have indicated the necessity of developing and adopting the principles of a bio-based economy, which promotes the use of waste biomass in the production of biofuels, biomaterials and biochemicals. The transition from a fossil-based economy to circular bioeconomy has created new challenges, since both resources and products have changed, waste is considered a resource and the process safety and environmental protection are at the highest level. Chemical engineering thermodynamics can help overcoming these challenges since the knowledge of thermophysical properties is the basis of process and product design and optimization. Most of the data on thermodynamic and transport properties that can be found in databases are related to the processing of a fossil oil. The use of renewable resources and the production of novel task-specific products require their detailed thermodynamic characterization. Reduction of waste generation, as well as its further use as a resource, requires a serious increase in the energy efficiency of the process, which is one of the basic tasks that thermodynamics deals with. Also, the recovery of chemicals and valorisation of waste is based on the use of novel eco-friendly, green solvents of high efficiency and selectivity, for which the knowledge of phase equilibrium behaviour of such systems is crucial. In addition to the lack of experimental data, the problem for the precise design of biorefineries is also the lack of accurate thermodynamic models. Most of the models used in process simulators were developed for the petrochemical industry, so it is necessary to examine their applicability in biorefineries and how to adapt them to new needs.

Thermodynamic characterization is necessary for the application of biofuels. Density and viscosity of fuel highly affect fuel atomization and combustion in diesel engines, and the isobaric thermal expansivity of fuel influences a diesel engine performance. Our study of biodiesel and diesel blends showed that biodiesel has higher density and viscosity, but lower isobaric thermal

expansivity (lower engine power loss) than diesel, indicating that the lower blends of biodiesel (up to 20 vol%) with diesel are recommended for use in diesel engine. In the case of waste biomass valorisation into potential platform chemicals, different chemical treatments require the development of microkinetic models that take into account the solubility of various gases in reaction mixtures. The prediction of phase-equilibrium behaviour of mixtures of hydrogen and biomass-based compounds, neglecting interaction between components, does not give satisfactory results, so it is of highest importance to optimize the binary interaction parameters for the mentioned systems based on the experimental data.

The development of predictive thermodynamic models of a wide application area is necessary, where the exceptional potential of molecular simulations should be exploited. This requires reliable and consistent thermodynamic data. Based on the above, thermodynamics has a key role in an efficient and most convenient transition from a fossil-based economy to a sustainable circular economy by providing precise data and models relevant for the sustainable processing of (bio)waste.

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Short biography: Dr. Gorica Ivaniš is Senior Research Associate at Faculty of Technology and Metallurgy, University of Belgrade, at the Department of chemical engineering. Her research interest and experience are related to the field of environmental protection, studying of “green” solvents, energy efficiency and process intensification and integration. She is teaching assistant at the faculty in Chemical Engineering Thermodynamics, Heat Integration and Energy integration of processes. Her research work is mostly related to the experimental determination and modelling of thermodynamic and transport properties of multicomponent systems, such as density, viscosity, vapour-liquid and liquid-liquid equilibrium, under different conditions of pressure and temperature. Dr. Ivaniš has published 23 papers in international journals from the ISI-JCR-SCI list and over 30 papers at (inter)national conferences and is co-author of 2 Technical solutions. According to the citation check (Scopus) her papers were cited 411 times (heterocitates) and her h-index was 14. She participated in more than 5 projects that dealt with the industrial application of thermodynamic properties, CO_2 recovery, waste and biomass valorisation, biofuel production, etc. In the period 2019-2021, she was a postdoc at National Institute of Chemistry, Slovenia, where she determined the solubility of gases in various biomass derived compounds for the needs of biorefining projects. Dr. Ivaniš supported the Serbian Competent Authorities and operators in the implementation of the IE Directive as Technical Expert at Cleaner Production Centre of the Faculty of Technology and Metallurgy, University of Belgrade.

Biomass feedstock utilization and analysis for SAF production

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Abstract:

Biomass waste feedstock will have a significant role in the near future adaptation of advanced biofuels, including sustainable aviation fuel (SAF), for meeting strict emissions regulations and European Union (EU) targets for reducing carbon dioxide (CO_2) emissions, and reaching net-zero CO_2 emissions by the year 2050. SAF is mainly produced from feedstocks of crops which give produce plant oils, and it is currently used by 0.05% in total aviation fuel consumed in the EU, and there is a target for reaching 2%, 6% and 70% of SAF in total aviation fuel by the years 2025, 2030 and 2050, respectively. The main objectives of the present research include firstly the survey of available biomass feedstock for large scale use in biorefinery thermal process conversion for advanced biofuel production, secondly the assessment and identification of the most efficient feedstock utilisation within the pertinent biorefinery process for efficient production of SAF. The final objective of the present research is the illustration and evaluation of the candidate biomass feedstock chemical components and characteristics, as well as to review the subsequent chemical pathways from published research for the optimal production of SAF. The methodology employed in the present work includes the thermodynamics and thermochemistry properties computation for the components of test biomass feedstock, and the life-cycle greenhouse emissions estimation for each test biomass feedstock used for SAF production compared against the baseline emissions for conventional jet fuel. In the present research, three test biomass feedstocks are examined, namely wood chips, maize residue and algae, and their chemical components and chemical pathways are collected from published research studies and used in the present investigations and comparisons. From the findings of the present work, the value-chain from field-to-tank for SAF production utilising the three different test biomass feedstocks is discussed, and recommendations for biomass feedstock quality requirements are outlined, in order to meet the specifications for SAF certification according to the demanding aviation fuel standards. Overall, it is envisaged that the adaptation of appropriate biomass feedstock along with advanced biorefinery technologies will lead to more sustainable aviation.

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Fungal biofilms for bioremediation: metal accumulation and waste recovery

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Abstract:

The use of fungi in materials science and industry is of growing interest, especially in the development of Engineered Living Materials (ELMs), where fungi can serve as living building blocks within material systems. Integration of living cells provides new functionalities, particularly in environmental applications. Moreover, fungi, particularly their mycelial networks, hold great potential for bioaccumulating metals and pollutants from contaminated waste streams, offering a sustainable solution for bioremediation and waste valorization. Through biosorption and biotransformation, fungal biofilms absorb, sequester, and remove metals from the environment, turning waste into a valuable resource. Fungi are widely recognized for their role in mycoremediation, with certain genera demonstrating remarkable capabilities for bioaccumulating and detoxifying metals and pollutants from various waste sources. Commonly used genera in mycoremediation efforts include *Pleurotus*, *Phanerochaete*, and *Trametes*, which have been extensively studied for their ability to colonize diverse substrates, including soils and industrial waste. Their extensive mycelial networks make them effective in bioremediation. One promising application is the development of mycelium-based carbon materials, sustainable by design alternatives to conventional materials in energy storage devices. The metals bioaccumulated in the fungal mycelium can be used to create eco-friendly components for batteries, supercapacitors, and other energy systems, aligning with green chemistry approaches. By utilizing fungi's bioaccumulation abilities, this concept supports the circular economy by transforming contaminated biomass into valuable resources for bio-based industries. This scalable, low-cost solution reduces environmental impacts and promotes resource recovery in waste management.

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Wojciech Pajerski is a postdoctoral researcher at InnoRenew CoE in Slovenia, specializing in microbiology, materials science, and nanotechnology. His work focuses on bioinspired materials and interfaces between microorganisms and surfaces. He is engaged in the ERC-funded ARCHI-SKIN project on Engineered Living Materials (ELMs) for eco-friendly architectural solutions. With patents in bio-based technologies, his research integrates green approaches to reduce environmental impact. His international collaborations and interdisciplinary expertise position him to advance sustainability and green technologies.

Estimating Food Processing By-Product Volumes Across the EU: A Comprehensive Assessment to Support the Circular Bioeconomy

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Abstract:

The EU Bioeconomy Strategy (EC, 2018) advocates for the utilization of secondary bio-based resources to produce value-added products, contributing to a circular bioeconomy. However, the lack of harmonized and quantitative data on the availability of these resources across different regions poses significant challenges for regional valorization efforts. Moreover, the UN Sustainable Development Agenda (UN, 2015) does not outline targeted actions for managing food processing by-products, nor is there a uniform reporting procedure for by-products like the one for food waste in the EU (EC, 2019). This has led to under-reported resource flows and suboptimal usage. Addressing this gap, a study by De Laurentiis et al. (2023) employed a material flow analysis across the EU food supply chain but lacked detailed estimates for specific by-products. Haller et al. (2022) emphasize that precise resource quantification can reveal underutilized resource flows, while Soloha et al. (2024) introduced a standard method for estimating by-product volumes in eight Northern European countries. Building on this work, the present study aims to expand the geographical scope to other European countries, facilitating an overall estimation of by-products across the EU and enabling cross-country comparisons.

This study utilizes the method developed by Soloha et al. (2024) to estimate by-products from the food processing and manufacturing industries in the EU. Data were sourced from the FAOSTAT "Food Balances: Supply Utilization Accounts" database, covering food production data from 2015 to 2021. Forty unique crop and livestock food products (excluding meat) were selected from the production data of processed products. By-product volumes were calculated using compiled data from scientific and grey literature for the corresponding processed food products. The study exclusively analyzed original research articles on bio-valorization, defined as the use of living organisms or their enzymes for valorization purposes, focusing on methods that utilize by-products derived from the selected crop and livestock products.

The study presents estimates of food industry by-product volumes for each of the EU-27 countries between 2015 and 2021. By-products are categorized into dairy, fruits and vegetables, roots and tubers, oils and fats, cereals, brewery and winery, and other categories (including eggs, coffee, groundnut, and cocoa). These estimates provide a detailed understanding of by-product availability and highlight significant differences among individual countries. This research offers crucial data-driven insights to support the development of the circular bioeconomy, providing a comprehensive overview of the total annual by-product volumes and their potential for bio-valorization. The findings underscore the need for further research to refine by-product estimates and assess their suitability for producing value-added products. Aligning by-product availability with regional circular bioeconomy growth potential is essential to address the environmental, technical, economic, and social challenges of transitioning to a circular bioeconomy. The study

highlights the importance of data-driven approaches to inform policy and practice, ensuring an efficient and equitable transition towards sustainable development goals.

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Short biography: Elina Dace holds a PhD degree in environmental engineering and a master's degree in social sciences. Her research work is characterized by multi-disciplinary and integrated application of quantitative and qualitative research approaches to study transition towards circular economy and climate change mitigation. She applies knowledge from environmental engineering, industrial biotechnology, and computational modelling to support decision makers in selecting valorization pathways of biowaste and bio-based side streams into value added products. She has published widely on modelling and assessment applications to various socio-technical systems as agricultural, forestry, waste management and energy systems.

Bioethanol Production from A-Starch Milk and B-Starch Milk by Simultaneous Saccharification and Fermentation

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Abstract:

Bioethanol is ethanol (C_2H_5OH) produced by the microbial activity of yeast cells through alcoholic fermentation of biodegradable raw materials containing carbohydrates. Bioethanol represents one of the most promising modern renewable biofuels worldwide. Currently, almost 60% of bioethanol global supply is produced by dry- or wet-milling of starch-based crops, such as corn, wheat, barley, sorghum, potato, sweet potato, cassava, etc. Wet milling of wheat has emerged as a versatile process that can improve the exploitation of all wheat grain constituents and contribute to the successful production of bioethanol. During wet milling of wheat flour, two main products are obtained, vital gluten and starch. Approximately 80-85% of wheat flour protein is found in the vital gluten fraction, while the remaining starch milk suspension is concentrated and separated into two fractions: A-starch milk and B-starch milk. The utilization of A-starch milk and B-starch milk, which are intermediate products in industrial wheat wet-milling, for bioethanol production represents an attractive option for wheat starch industries to increase flexibility and respond to market conditions depending on current starch and bioethanol prices. This biorefinery concept could potentially increase the profitability and productivity of the process, and contribute to the establishment of the efficient production of bioethanol, along with the production of starch and gluten. In this study, the potential of A-starch milk and B-starch milk as feedstocks for bioethanol production was experimentally investigated by simultaneous saccharification and fermentation (SSF) using distillers' yeast Saccharomyces cerevisiae. The results indicated that A-starch milk and B-starch milk represent perspective raw materials for bioethanol production, considering substantial starch content of 83.22% (per dry matter) and 68.08% (per dry matter), respectively. In this work, starch liquefaction of starch milk samples was performed enzymatically by technical alpha-amylase, followed by simultaneous saccharification using glucoamylase and fermentation by yeast. The maximal ethanol yield reached 55.18 mL per 100 g for A-starch milk and 45.56 mL per 100 g of dry matter for B-starch milk, confirming that starch milk samples are highly reliable feedstocks for bioethanol production. Moreover, the utilization of starch milk regarding the portion of fermentable starch in total starch was 92.15% for A-starch milk and 92.97% for B-starch milk indicating high yield in comparison with theoretical yield (90-93%) and confirming the success of the implemented process. According to the achieved results, A-starch milk and B-starch were confirmed to be excellent raw materials for bioethanol production by simultaneous saccharification and fermentation with possibility of integrating industrial production of starch and gluten through biorefinery concept.

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Short biography: I am a PhD student in Biotechnology study program at Department of Biotechnology, Faculty of Technology Novi Sad, University of Novi Sad, Serbia. I am at the beginning of my professional career as a researcher in the field of Biotechnology. Research topics of my interest are Industrial and Environmental Biotechnology and Sustainable Waste Management. Accordingly, I have focused on developing experiments in which I am trying to apply low-cost substrates to make an industrially important and high-value bioproducts, especially bioethanol.

Utilization of Activated Carbon from Orange Peel Waste for Reducing Formaldehyde Emissions in Particleboard

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Abstract:

The wood-based composite industry faces significant challenges related to the emission of formaldehyde from particleboards, which poses both health and environmental risks. One potential solution involves converting orange peel waste, which is problematic to store and decompose, into activated carbon (AC). This approach not only valorizes the waste by producing a valuable product but also contributes to a healthier environment by reducing formaldehyde emissions. This study explores the incorporation of AC into urea-formaldehyde (UF) adhesive as a strategy to reducing the formaldehyde emissions from particleboard. The AC, derived from orange peel through potassium hydroxide activation, is used as an additive. 50 g orange peel, washed with distilled water and dried, is treated with 500 mL of 7% KOH solution and left at room temperature for 24 h. Subsequently, the orange peel is dried at 80°C. Orange peel activated with potassium hydroxide was subjected to pyrolysis by exposing it to nitrogen gas flow (55 mL/min) at 700 ºC for 90 min. Potassium hydroxide activation produces high-quality AC from orange peel with a BET surface area of 762 m^2/g and an AC production yield of 32.92%. The AC's Raman spectra show two bands at 1592 and 1325 cm^{-1}, confirming a graphite-like structure. Scanning electron microscopy (SEM) images show that AC has the porous structure. The inclusion of AC at varying levels (0.0%, 2%, 5%, and 8%, based on the dry weight of the adhesive) shows significant promise in reducing formaldehyde emissions, with reductions of up to 38% at post production. These improvements align with environmental and health safety standards, making this solution highly attractive to the wood-based composite industry. On the other hand, using biomass waste like orange peel as a raw material for AC production not only supports waste management efforts but also promotes the circular economy.

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Determination of antioxidant capacity of protein hydrolysates from agricultural organic waste carrot tissues

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Abstract:

Carrot (*Daucus carota* L.) is a widely cultivated and economically important root vegetable, recognized for its rich composition of nutrients and bioactive compounds that are beneficial to human health. In recent years, there has been growing interest in the extraction and utilization of bioactive peptides from plant sources, including carrots, due to their potential health-promoting properties. Bioactive peptides are specific protein fragments that, when released from their parent proteins through enzymatic hydrolysis, can exert various positive effects on bodily functions, making them promising candidates for therapeutic applications. These peptides are known for their diverse biological activities, including antioxidant, antimicrobial, antihypertensive, and immunomodulatory effects. Unlike conventional molecular drugs, biopeptides offer several advantages such as a broader therapeutic spectrum, lower toxicity, and the ability to target multiple physiological pathways. Protein hydrolysates, which are mixtures of polypeptides, oligopeptides, and amino acids produced through the partial or extensive hydrolysis of proteins, have emerged as a rich source of bioactive peptides. Enzymatic hydrolysis is commonly used to release these peptides from plant tissues, with enzymes like Flavourzyme 500 L facilitating the process. In this study, carrot tissues that were deemed unsuitable for market after harvest were utilized as a raw material for enzymatic hydrolysis, aligning with efforts to reduce agricultural waste and promote sustainable practices. The antioxidant activities of the resulting carrot protein hydrolysates were measured using three well-established in vitro antioxidant assays: ABTS, FRAP, and ORAC. These assays revealed significant antioxidant potential, with values ranging from 3.34 to 42.06 µM TE g^{-1} protein. The findings suggest that carrot-derived hydrolysates possess considerable antioxidant activity, highlighting their potential as a valuable source of bioactive peptides. Moreover, this approach not only contributes to the development of functional food ingredients but also supports the recycling of organic agricultural waste, reinforcing the principles of circular agriculture and bioeconomy.

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Harnessing *Aureobasidium pullulans* for Bioremediation of Lignin Derivatives in Biorefinery Wastewater

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Abstract:

Wastewater from biorefineries often contains high concentrations of complex organic pollutants, including lignin-derived phenolic compounds, which are toxic and difficult to degrade using conventional wastewater treatment methods. Efficient treatment of wastewater containing lignin derivatives remains a significant challenge in biorefinery operations, impacting both process economics and environmental sustainability. Fungi offer promising potential in bioremediation due to their ability to produce extracellular enzymes that degrade complex organic molecules, including recalcitrant pollutants such as lignin. Their adaptability to diverse environmental conditions and ability to form biofilms further enhance their capacity to break down and metabolize these compounds, making them valuable in treating contaminated wastewater.
This study aims to investigate the potential of *Aureobasidium pullulans*, a polymorphic black yeast-like fungus known for its resilience, phenotypic plasticity, and ability to produce various extracellular enzymes, to bioremediate lignin-derived compounds in biorefinery wastewater streams. We observed and quantified the fungal growth patterns and morphological changes of *A. pullulans* in lignin derivative over time using time-lapse imaging with a transmitted light system (EVOS M7000, ThermoFisher Scientific). The obtained results demonstrate significant variations in colony form, dimension, and cellular morphology across different lignin derivatives, highlighting *A. pullulans'* remarkable phenotypic plasticity. These findings provide valuable insights into the dynamic interactions between *A. pullulans* and lignin-derived compounds in wastewater, opening new avenues for the biological treatment of biorefinery effluents. The ability of *A. pullulans* to adapt to and metabolize these compounds suggests its potential use in biorefinery wastewater treatment processes. This research contributes to the development of more sustainable biorefinery operations by addressing the critical challenge of wastewater treatment. By demonstrating *A. pullulans'* potential to remediate lignin derivatives while potentially generating valuable byproducts, our study advances both environmental protection and resource recovery in the bioeconomy.

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Human Health Aspects in Waste Biorefinery Technologies and Products

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Abstract:

Climate change serves as a powerful catalyst, urging us to reevaluate our relationship with the planet. Its negative impacts are most notably seen in rising CO_2 levels, which drive global temperature increases, as well as the growing waste production. Acknowledging these challenges has sparked the development of biorefinery technologies aimed at producing cleaner energy and sustainable products. Beyond reducing environmental harm, these innovations can indirectly benefit human health and well-being. However, when introducing any product for human use, we must also consider its direct impact on the human body. Although biorefinery technologies generate bio-based products, this doesn't automatically guarantee they are entirely safe for human health. Engineered living materials (ELMs) offer a promising avenue within biorefinery technologies, as they combine biological functions with structural capabilities, potentially enhancing sustainability and reducing waste. However, given their dynamic nature, it is essential to thoroughly evaluate the interaction between these materials and human health to ensure they are safe for direct or indirect human exposure. Therefore, it is crucial to assess their potential influence on health to optimize production processes and ensure truly sustainable products that pose no harm to human health. One simple and effective method to evaluate the safety of these products is cytotoxicity testing. This involves testing the substance or product on human cells *in vitro* and observe their response to it. After exposure, the viability and morphology of the cells are examined to detect any potential toxic effects. As the famous Latin phrase reminds us, "*sola dosis facit venenum*" (the dose makes the poison) - even essential molecules like vitamins can be harmful if consumed in excessive amounts. This highlights the importance of determining the safe dosage for any substance we are exposed to. In the context of biorefinery technologies, understanding the balance between environmental friendliness and human safety is key to developing products that are both sustainable and non-toxic.

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Short biography:
Valentina Hribljan holds a Master's degree in Molecular Biology and a PhD in Biomedicine (Neuroscience). During her PhD, she focused on the effects of stem cells on the recovery of neural cells injured by hypoxia-ischemia. From January 2024, she is employed in the Materials Department at InnoRenew CoE, where one of her primary responsibilities is assessing the cytotoxicity of various materials.

Valorization of Duck Feathers in Biorefineries: Advancing Sustainable Bioenergy and Bioproducts in the Circular Economy

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Abstract:

Keratinous wastes, including feathers, hair, wool, claws, and hooves, represent a significant global waste stream, with poultry feathers being particularly abundant. Worldwide, the poultry industry generates millions of tons of feathers annually, contributing to environmental challenges due to improper disposal methods such as incineration and landfilling. In Europe, approximately 3.6 million tons of feathers are produced each year, with France leading in duck production, particularly in the southwest, where the average annual feather production reaches 16,892 tons as a byproduct of the 207,267 tons of duck produced annually.

This study investigates the valorization potential of duck feathers from the French mulard species for biorefinery and bioenergy applications. A comprehensive analysis of these feathers revealed that they contain volatile matter (80-86%), fixed carbon (5-10%), ash content (0.5-1.5%), and moisture content (7-10%). The protein content, determined using the Kjeldahl method, is 82.97 ± 0.98%, corresponding to a nitrogen content of approximately 13.28%. With an average heating value of 15-16 MJ/kg, the feathers primarily consist of β-keratin with a molecular weight of 10 kDa, and their thermal degradation occurs between 230 and 245°C. The study categorized the feathers by size, including the main parts—rachis, barbs, and calamus—and found consistent properties across these categories, making them suitable for bioenergy conversion without the need for further sorting.

This work highlights the potential of integrating duck feathers into sustainable biorefinery processes, contributing to the circular bioeconomy and mitigating environmental impact. By optimizing the pretreatment, collection, and conversion of these keratinous wastes, the research aligns with WG1's goals to advance the bio-based circular economy. The work will focus on how the nitrogen content and keratin in feathers can be effectively utilized in biorefinery applications, transforming waste into valuable resources such as biofuels, biopolymers, and other high-value products, thereby enhancing both the sustainability and profitability of the poultry industry.

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Renewable Substrates for Moesziomyces spp. cultivation: The Example of Cheese Whey as Yeast Extract-Free Media for Efficient β-Galactosidase and Biosurfactants Production

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Abstract:

Microbial biosurfactants have potential to replace fossil driven surfactant with positive environmental impacts, lower ecotoxicity and higher biodegradability. Mannosylerythritol lipids (MEL) are extracellular secreted glycolipids and, given their low critical micelle concentration and surface-active properties, one of the most promising microbial surfactants. Due to their unique structure MELs present various activities, such as antimicrobial, antitumor, antioxidant and anti-inflammatory activity, skin and hair repair capacity, which opens possibilities for their use in applications from cosmetics and pharmaceutics to bioremediation, agriculture and biofuels for aviation (due to their medium carbon chain length in the fatty acid moiety).

However, their market share is still low when compared to other glycolipids, due to their less developed production process and higher production cost by the lack of bioprocesses capable of attaining high titres from cheap renewable raw materials. The use of glucose as carbon source, together with yeast extract is one of the major bottlenecks since it can be cost-prohibitive and not sustainable. In addition, *Moesziomyces* spp. are known to be, not only competent MELs producers, but also to be able to express a wide range of enzymes, such as lipases and xylanases. The current work studies the potential use of cheese-whey, a by-product of cheese industry, for medium preparation for MEL fermentations and investigates the *Moesziomyces* spp. ability to express β-galactosidase.

Herein, we report for the first time β-galactosidase production by *Moesziomyces* spp..: D-galactose was the best β-galactosidase inducer, with 11.2 and 63.1 IU/$mg_{biomass}$, for *M. aphidis* 5535T and *M. antarcticus* 5048^T, respectively. Remarkably, when cheese whey was used as solo media component (carbon and mineral source), in combination with waste frying oil, MELs productivities were very close (1.40 and 1.31 g_{MEL}/L/day) to the ones obtained with optimized medium containing D-glucose, WFO, and yeast extract and minerals (1.92 and 1.50 gMEL/gsusbtrate), both for *M. antarcticus* and *M. aphidis*, respectively. Those are promising results on further MEL bioprocess development supported on low cost, facile and efficient processes to generate large amounts of MELs, potentiating its industrialization.

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Short biography: I graduated in Biomedical Engineering from Universidade do Minho and earned a PhD in Bioengineering from Instituto Superior Técnico, Portugal in 2014, focusing on producing jet biofuel from renewable resources in collaboration with LNEG (Portugal), and MIT(USA). Since then, I have been a Post-doctoral and Junior Researcher at DBE and iBB, and in 2019, I became an Invited Assistant Professor. My work focuses on developing cell factories and enzymes for converting renewable substrates into valuable products, advancing yeast biotechnology for biofuels and chemicals, and supervising MSc and PhD students while collaborating with academic and industrial partners.

Utilization of oak bark-derived residuals in water-based wood treatments

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Abstract:

The demand for sustainable wood treatments has increased, with a focus on solutions that enhance wood performance while adhering to circular economy and green principles. Modified and engineered wood products have demonstrated improved service life, but further advancements are needed to develop eco-friendly treatments suitable for industrial upscaling. One potential resource is bark, a by-product of forestry operations used typically for energy generation, animal bedding, or mulching. However, bark also holds significant potential as a feedstock for bio-based wood treatments. This study explores the use of residual oak bark (*Quercus robur*) in water-based wood treatment and aims for the comprehensive utilization of residual biomass fractions. Wet outer oak bark was dried, milled (1-4 mm), and processed using three distinct methodologies: (1) ultrasonic cavitation extraction with Eth-H_2O mixtures, (2) alkaline aqueous extraction with NaOH in a pressure reactor, and (3) thermochemical conversion to biochar, with the recovery of water-condensed fractions. After extractions, the remaining bark material was further subjected to thermal conversion into biochar. The resulting solutions were characterized and formulated into water-based wood impregnation treatments with appropriate additives. Scots pine (Pinus sylvestris) samples were vacuum pressure impregnated with these formulations at room temperature and then evaluated for key performance indicators, including leachability, dimensional stability, wettability and UV stability. The results highlight both the strengths and limitations of each treatment approach, demonstrating the effectiveness of bio-based treatments derived from oak bark residuals. Furthermore, the extraction methods significantly influenced the properties of the resulting biochar, impacting its potential applications. This research advances the development of sustainable wood treatment strategies while maximizing the value of forestry by-products.

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Rene Herrera is a researcher at the University of the Basque Country UPV/EHU in Spain, focusing his research on innovative strategies to improve critical wood properties, non-destructive characterizations and sustainability and green technologies. His 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).

Metal retention: an opportunity for the application of olive pomace biochar

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Abstract:

This review examines the capacity of olive pomace, a by-product of the olive industry, as a precursor for biochar production. It provides a comprehensive overview of the olive sector, which is of significant global importance, particularly in the Mediterranean region. This region is the world's largest producer of olives and olive oil, accounting for 90% of global production. The paper also addresses the environmental challenges posed by the significant amount of waste generated by this industry, estimated at around 15 million tonnes per year, in the form of pomace. This waste has a significant environmental impact, particularly on communities located near processing facilities.
The study examines the potential for converting this waste, which poses an environmental challenge due to its sheer volume, into biochar. It reviews the main methods for producing this carbonaceous material. The analysis then shifts to the potential applications of biochar for metal retention, particularly metals such as silver and arsenic, via adsorption processes. These applications cover various sectors, including mining, water treatment and environmental remediation, among others. The results discussed in this section highlight the promise of valorising olive pomace by converting it into biochar, a carbon material with a well-developed porous structure and tunable surface chemistry that can be optimised for specific applications in the retention or removal of metals from liquid phase systems.

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Development of an Investment Decision Tool for Biogas Production from Biowaste

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Abstract:

Biomethane is the Renewable Energy Source (RES) derived from the purification of biogas produced from Anaerobic Digestion (AD) process using biomass. Biomethane can be injected into the natural gas grid, thereby contributing towards satisfying the energy demands of society. The aim of this work is to test an investment decision tool for assessing the financial feasibility of an AD plant using biowaste for producing biogas and, then, biomethane, as well as digestate and, then, compost. The first Sicilian AD plant aimed at producing biomethane was built in the province of Caltanissetta in 2021.The innovative Enersi Sicilia plant treats 56,000 t of Organic Fraction of Municipal Solid Waste (OFMSW) per year to generate 499.22 Sm^3h^{-1} of biomethane. This plant yields a yearly total of 4,168,483 Sm^3 of biomethane, thereby replacing 8,450 t of oil equivalent and avoiding the emission of 6,126 t of fossil CO_2 into the atmosphere. The solid fraction of digestate is recovered and processed into compost, that corresponds to approximately 25–30% of the original feed in biomass weight. This compost is classified as a “mixed composted soil conditioner”, that can be used in agriculture, within Circular Bioeconomy (CBE). The financial feasibility of AD plant case study was assessed through Cost-Benefit Analysis (CBA), by assuming a reference period of 20 years, both with and without the financial subsidy provided by the Italian government to those who market biofuels, i.e. certificate of introduction in consumption. The reliability and robustness of CBA results were verified through the Sensitivity Analysis (SA). Even without the subsidy, the AD plant proved to be a good financial investment, without taking into consideration all its social and environmental benefits. The financial feasibility of the investment would be preserved up to an 8.21% yearly increase in the operational costs.

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BIOPROCESSES STRATEGIES TO ENHANCE BIOBUTANOL PRODUCTION VIA ACETONE-BUTANOL-ETHANOL (ABE) FERMENTATION

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Abstract:

The increasing global energy demand contrasts with the dwindling availability of fossil fuels, driving the need for alternative renewable energy sources. Undoubtedly, biobutanol is a major biofuel type with physical and chemical properties similar to that of gasoline. This makes it a perfect renewable alternative to fossil fuel which has generated environmental concerns in the last two centuries. Pretreatment, Acetone-Butanol-Ethanol (ABE) fermentation and product separation are the main processes to achieve biobutanol production. Lignocellulosic biomasses have been widely studied in biobutanol production. While lignin, a major component of lignocellulose is difficult to degrade, the pretreatment and fermentation processes leads to its breakdown, improving overall biomass digestibility and contributing to the production of biobutanol. Often, the need for a pretreatment optimization study is always necessary to achieve the best fermentable sugar concentration that goes into the fermentation process. Parameters like pH, temperature (T), time (mins), substrate concentration (g/L), substrate diameter (D_p) and power (W) significantly affect the pretreatment procedures. Microwave (MW) and autoclave (AC) pretreatment was conducted on fig hydrolysis for fermentable sugar production in this study. The maximum fermentable sugar concentration of 82.91 g/L and 70.02 g/L were obtained from MW and AC hydrolysis, respectively, with optimized hydrolysis conditions of MW as D_p = 370.72 µm, pH 4.96 and P = 253.67 W and for AC as D_p = 263.19 µm, pH= 3.02, T = 1200C and t = 30.00 mins. The desire to have an improved biobutanol concentration and elimination of inhibitory products like hydroxyl-methyl-furfural (HMF) often accompanying pretreatment is always the goal of scientists working on biobutanol. Recent strategies to combat the challenges faced in biobutanol production include adoption of consolidated bioprocessing, a cost-effective option that combines pretreatment and fermentation together. Also, electron mediators like methyl viologen (MV) and neutral red (NR) have also been reported to favor Nicotinamide Adenine Dinucleotide (NADH) levels and diverting biochemical pathway to favor biobutanol rather than hydrogen (which is a gaseous fermentation product). The experiment conducted in this report shows that 0.1 mM MV and 1mM NR are enough to divert the ABE fermentation pathway to favor biobutanol (6.79 g/L) production. Furthermore, cations like Zn^{2+}, Na^{+} and Mo^{3+} addition to fermentation medium has been found in this study to activate butanol production enzymes (butyrylaldehyde dehydrogenase & butanol dehydrogenase), thus favoring butanol production over other ABE products (i.e., ethanol and acetone). Zn^{2+} (0.1 mg/L). Na^{+} (60 mg/L) and Mo^{3+} (0.5 mg/L) were found to be the best concentrations favoring biobutanol production (6.5 g/L) from fig. Often, pretreated or hydrolyzed lignocellulose biomasses often contain these elements. However, an optimization study is always necessary to determine if the concentrations of these metals is

enough to support microbial performance for butanol production or the need for an external addition of the metallic salts. This is because elemental concentrations of pretreated lignocellulosic biomass differs. Thus, this paper considers the pretreatment, fermentation, metabolic pathway and bioprocess strategies to enhance biobutanol production from organic waste materials.

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Short biography: I am a professor in the Department of Environmental Engineering at Dokuz Eylul University, where I have been teaching courses on Waste Bioconversion, Bioprocess Engineering, and Biofuel Production. For the past 20 years, my research has focused on waste processing, specifically the bioconversion of waste into valuable products, often referred to as waste valorization. I instruct on methods and technologies for transforming various types of organic waste into value-added products. I have authored over 50 research articles on topics such as wastewater treatment, biohydrogen, and biobutanol production, as well as contributed chapters to international books.

Valorisation of Fish Canning Industry Residues for Biosurfactants Production

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Abstract:

Mannosylerythritol lipids (MELs) are glycolipids with high commercial potential, produced by non-conventional yeasts through fermentation processes. Not only they have surface tension reducing capacity, like the common surfactants, but they also present antioxidant, antimicrobial and ceramide-like activity, and others, thus they can be applied in a wide variety of fields, from food to cosmetics. And, unlike most synthetic surfactants they have low ecotoxicity, high biodegradability, and are biocompatible. Despite their advantages, MELs production is still not economically competitive with the other surfactants, thus, several ways to reduce costs are being studied.
Cost reduction strategies can range from yield optimization, through fermentation parameters variation or strain genetic engineering, downstream optimization, and replacement of refined substrates by industrial by-products with low commercial value, among others. Currently, at 2BRG-iBB IST Portugal, the potential of fish cannery oil residues to produce MELs is being studied.
Fish canning industry is a vital sector within the global food market, having an estimated market share of 31.37-33.3 bn USD in 2022 worldwide, and an expected compound annual growth rate of 5.9-6.2% until 2030-31. This industry generates residues that are mainly composed of 3 fractions: solids, water and oil. The solid residues have valorisation routes very well established, mainly for feed, fish meal and pet food. As for the oil fractions, the valorisation is very dependent on their degradation state and requires extensive purification processes to produce fish oils that can be used in human consumption or technical applications.
In this study, fish cannery oil residue pre-treated with a centrifugation step were used to replace hydrophobic carbon sources (sunflower oil) in the fermentation media. Preliminary fermentation studies allowed MELs titres of 22.98 g/L with 92.5% purity, a similar or increased value compared to control values done with refined vegetable oils, 17.88 g/L 89.5%. A water effluent from the same factory was used to replace Mili-q water from the fermentation media, and MELs titre and purity values achieved were 13.96 g/L and 69.5%, respectively.

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Short biography: Joana Almeida finished her master's degree in Biotechnology at Instituto Superior Técnico in 2023, currently she is a PhD candidate in Bioengineering on an industrial vertent. Joana works with glycolipid biosurfactants called mannosylerythitol lipids, which are produced by non-conventional yeasts through fermentation processes. Her work focuses on the characterization and assessment of agro-industrial wastes' potential to replace refined media components, and she is also working on the downstream optimization of the process. During her PhD, it is expected that she will explore the applications of this biosurfactant in the cosmetics industry.

Biorefinery conversion technologies towards carbon neutrality

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Abstract:

The European Union is dedicated to achieving economy-wide climate neutrality by 2050 to limit global warming to 1.5 °C. To this end, an extensive policy framework has been developed, aiming to reduce carbon emissions by at least 55% by 2030. Key regulatory changes include the phase-out of free EU emissions allowances and the implementation of the Carbon Border Adjustment Mechanism (CBAM). The EU plans to utilize industrial carbon management to mitigate hard-to-reduce emissions and achieve net-zero emissions by 2050. Although technological solutions for CO_2 transport, utilization, storage, and capture are readily available, they need to be deployed on a large scale across existing industries, including for those focused on biorefinery conversion technologies. Captured CO_2, especially from the atmosphere or biological resources, is expected to become a valuable commodity. By 2050, more than half of the captured CO_2 should originate from direct air capture or biogenic sources.
Bioenergy with carbon capture and storage (BECCS) is a technology that captures and permanently stores CO_2 produced when biomass is converted into fuels or burned for energy. Since plants naturally absorb CO_2 as they grow, BECCS effectively removes carbon from the atmosphere, making it a key tool in reducing greenhouse gas emissions and supporting the low carbon energy transition. Pulp & paper industry is the fourth most energy-intensive industry worldwide, with estimated emissions of more than 300 Mt CO_2/year and contributing to 2% of the global industrial GHG emissions. The inherent decarbonization of the Kraft process, the major traditional method for pulp and paper production, through the integration of Calcium Looping (CaL) for CO_2 capture, offers significant techno-economic advantages.
CaL is one of the most promising technologies for post-combustion CO_2 capture and thermochemical energy storage based on the following reversible chemical reaction: $CaO\ (s) + CO_2\ (g) \rightleftarrows CaCO_3$. The advantageous of CaL includes the high CO_2 sorption (0.78 g CO_2/g CaO), high energetic density (1790 kJ/kg $CaCO_3$), availability and low price. By incorporating CaL into the existing lime cycle, material costs can be reduced, as part of the fresh limestone is replaced by lime mud. Additionally, CaL enhances the process's heat recovery potential, further improving the overall efficiency and cost-effectiveness of the Kraft process.

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Pyrolysis of End-of-Life Tires in Erzincan, Turkey, and Power Generation from Pyrolytic Oil

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Abstract:

Erzincan, a province in eastern Turkey with industrial potential, requires innovative solutions for waste management and energy production. In this study, a pyrolysis plant was established in Erzincan to recycle waste tires. This study on the pyrolysis of end-of-life tires in Erzincan, Turkey, and the power generation from pyrolytic oil highlights the importance of environmentally friendly and sustainable energy sources. Recycling waste tires without harming the environment provides significant environmental and economic benefits. Pyrolysis is the thermal decomposition of organic materials in the absence of oxygen. During this process, waste tires are thermally decomposed at high temperatures (usually between 300-900°C). The pyrolysis process results in three main products which are pyrolytic oil, carbon black and gas products. Due to its high energy content, pyrolytic oil can be considered an alternative fuel source. This study investigated the feasibility of using pyrolytic oil for energy production. Electricity was generated by burning pyrolytic oil in power plants or using it in generators. Preventing waste tires from being directly disposed of in the environment helps reduce air, water, and soil pollution. Also, recycling waste tires into high-value products contributes to the local economy. Additionally, energy production reduces dependence on external energy sources. Thus, the power plant supplies environmental and economic benefits. The pyrolysis of waste tires in Erzincan and the power generation from pyrolytic oil offer an environmentally friendly and sustainable energy solution. This study provides significant findings that contribute to local and national waste management and energy policies. Implementing innovative methods in recycling and energy production lead to important steps toward a more sustainable environment and economy.

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Biorefinery concept in the livestock sector

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Abstract:

Waste management in pig farms, one of the most traditional agro-industries in Portugal and Europe, is a serious environmental problem. These industries produce large quantities of effluent with high organic and inorganic loads, some of which are highly refractory. Traditional treatments of these effluents involve biological methods such as composting, anaerobic digestion (AD), or lagooning. However, biological techniques alone do not represent a complete solution for treating these effluents due to significant efficiency losses and low biodegradability, and the treated effluent does not reach the required purification levels. In this way, integrating different technologies in a biorefinery context becomes attractive for tackling the complex challenges of waste management on pig farms, offering a comprehensive and sustainable approach that goes beyond the limitations of traditional biological methods. This integration could combine anaerobic digestion, electrochemical technologies, and gasification to produce renewable gases (e.g. biogas, hydrogen, and synthesis gas). Overall, developing a concept based on this integrated technology could be applied in situ using the effluents generated on pig farms, thus, improving both the effective management of the waste generated and the energy self-sustainability of the process. In addition, by electrolyzing the aqueous phase of the process, the project not only reduces dependence on drinking water but also generates hydrogen, contributing to the transition to a low-carbon economy. This concept of double recovery of pig farm effluent is in line with international efforts to explore sustainable solutions for wastewater management, renewable energy production and the principles of the circular economy.

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MODELING CONTROL OF METHANE AND HYDROGEN PRODUCTION IN BIOREFINERIES

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Abstract:

Biogas production using sludge is a globally growing market, in addition to agricultural wastes. In the coming years, bioenergy will be the most significant renewable energy source, because it started to offer an economical attractive alternative to fossil fuels. The success of biogas production will come from the availability at low costs and the broad variety of usable forms of biogas for the production of heat, steam, electricity, and hydrogen and for the utilization as a vehicle fuel. Many sources, such as crops, grasses, leaves, manure, fruit, and vegetable wastes or algae can be use, and the process can be applied in small and large scales. This allows the production of biogas at any place in the world. The biggest challenge in the implementation of more recent and efficient unit operations of process to the currently functioning refineries!
In this research, we evaluated the efficiencies of H_2 gas or CH_4 in engineered systems and compared it to different natural production processes. A basic model is developed its efficiency and the sensitivity of the model is evaluated. The model is used to evaluate an animal rumen and a sludge digester, which have two different feedstock and they are not compared for their energy rather a symbiosis potential is investigated. This process model has the potential to be implemented with a GIS approach, also. Our theoretical evaluation shows that sludge can be more effective food stock for energy production compared to plat feed stock. Moreover, digester efficiency can be enhanced with the preliminary thermal processing operations.

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Low-cost Electrodes Configured as Biomass Retainer Enhance Biogas Production

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Abstract:

The Microbial Electrolysis Cell (MEC) is a promising technology that can be an alternative and sustainable technique for the treatment of waste streams and harvesting bioenergy from organic sources. Previous research indicates 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, such as inadequate treatment, low-rate biogas production, and elevated hydraulic retention time (HRT), a combined MEC+AD system was applied for harvesting biogas from chicken manure (CM), which is rich in nitrogeneous compounds and requires an essential treatment. The objective of this study was to increase biogas production in a combined MEC+AD reactor structured with low-cost electrode (activated carbon pellets, carbon fiber cloth) design and operated at high organic loading rates (OLR). The electrodes were surrounded with a plastic net to hold electrodes together and tight and maintain biomass retention on it. The anode electrode was a piece of carbon fiber cloth (3k twill weave, thickness:0.3 mm, weight: 200 g/m^2, 47 cm in length and 40 cm in width - folded in two). It was then covered by a plastic net to make it stand firmly in the reactor and support biofilm attachment and biomass retention on the surface of the carbon cloth and plastic net. The cathode electrode was a cylindrical plastic net chamber (L: 18-19 cm, Ø: 4.0–4.2 cm) filled with 150 grams of activated carbon pellets (Ø: 2.5 mm, H: 3-7 mm). This cathode design was also convenient for the biofilm support and biomass retention on the pellets. Both electrodes were ensured to contact the titanium wire (Ø: 1.5 mm) that will provide the electrical conductivity outside of the reactors. Three different reactors, namely control (AD-without electrodes), biofilm reactor (open circuit MEC+AD), and MEC+AD$_{0.3}$ (MEC+AD supplied with a voltage of 0.3V), were operated four sets at HRTs from 20 days to 3 days. The OLR of fed manure increased from 3 to 20 g VS/L/d by lowering the HRT. The results showed that MEC+AD0.3 and biofilm reactor presented a stable process throughout the study where as, the control reactor collapsed in Set 3 (OLR:12 g VS/L/d, HRT:5 days). The average biogas productions and methane yields obtained from the reactors were as high as 4.02 L_{bio}/L_R/d and 373 ml CH_4/g VS, respectively. Concerning the nitrogen content of the CM used in the study, NH4+ concentration in the reactors varied between 100 and 300 mg/L during the study, indicating no ammonium inhibition on the process. Energy assessments of (MEC+AD)$_{0.3}$ showed that in the 3rd set (HRT:5 d and OLR:12 g VS/L/d) the energy of the additional methane produced in MEC+AD was 16 times higher higher than the energy given to the system by the power supply unit (1600%). The coulombic efficiencies of the MEC+AD reactors varied between 1.3 and 47.6% according to the applied voltage and COD removal efficiencies which are both can be increased by using more conductive electrode materials.

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Valorization of crude glycerol as a biodiesel production by-product in the microbial biomass production

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Abstract:

Due to the increasing negative impact on the environment and human health, there was a need to find alternatives to chemicals for plant protection and to apply the sustainability concept. Biopesticides represent a solution to this problem, and scientists have focused on their production. However, the price of the cultivation medium can significantly affect the cost of production, so it is necessary to find an alternative medium. The production of biodiesel could generate 10% of waste glycerol, and an increase in biodiesel production would raise the problem of finding efficient treatment or utilization of waste glycerol. However, some microorganisms have ability to assimilate waste glycerol and convert it into value-added metabolic products. Therefore, considerable interest has been shown in usage of different wastes and by-products as cultivation medium, in order to reduce the production costs. Regarding this fact, waste glycerol seems to be promising component in cultivation media used for production of microbial biomass. Thus, the waste of one branch of industry can become the raw material for another industry, whereby a new product is obtained. At the same time, the amount of effluents that need to be processed before being released into the environment is reduced and this significantly affects the protection of the environment. As part of this research, crude glycerol obtained as a waste after biodiesel production was used as a medium for the production of *Trichoderma harzianum* biomass. Bioprocess was carried out in 3 L bench-scale bioreactor (Biostat® Aplus, Sartorius AG, Germany) during 72 hours, at 27 °C with aeration rate of 1 vvm and agitation rate of 300 rpm. The aim of this research was to analyse at which stage of bioprocess production of *Trichoderma* biomass effective against two maize phytopathogenic fungi occurs. In vitro antifungal activity of the produced *T. harzianum* cultivation broth against *Fusarium graminearum* and *Aspergillus flavus* were determined every 6 h using wells technique. The obtained results showed that the maximum antifungal activity of *Trichoderma* cultivation broth against selected test phytopathogenic fungi is achieved during 42 h of cultivation. The mean values of the inhibition zones diameter against *F. graminearum* and *A. flavus* reach values of 41.67 mm and 24.33 mm, respectively. These results show the great potential of using *T. harzianum* biomass in the biocontrol of maize phytopathogens, but also the great potential of using the biorefinery concept in the production of *Trichoderma* biomass. Certainly, the obtained results represent an important step for further development and *scale-up* of this bioprocess.

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Field of research: biotechnology, biochemical engineering, industrial microbiology, waste utilization…

Innovative industrial symbiosis concept for improvement of bioethanol production circularity

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Abstract:

Interest in bioethanol production technology is primarily a consequence of dramatic changes in market demands regarding the quantity and quality of bioethanol traded. In the last fifty years, bioethanol has been produced as a high-tonnage industrial chemical and then as biofuel with the required performance. It was popularized during the COVID-19 pandemic as an active substance in disinfectants. Different bioethanol applications require appropriate quality, which is causally related to the utilized raw materials, as well as to the production technology. Raw materials that are widely exploited are agro-industrial intermediates and byproducts. It is possible to use cheaper and more available raw materials by isolating new and/or improving the production characteristics of common biocatalysts. Further, the continuous invention of novel applications of bioethanol as a product of known technology in already installed production capacities makes it market topical. Obviously, bioethanol production is a technological procedure that corresponds to the circular economy challenges in its most demanding goals (9R's of Circularity), such as the reduction of natural resources consumption (R2 Reduce), the intensification of product usage (R1 Rethink), as well as the placement of product as substitutes for those with an undesirable impact on human health and the environment (R0 Refuse). The connection of improved bioethanol production with other technologies within the industrial symbiosis also contributes to the achievement of the highest level of circularity. In this study, an innovative concept of industrial symbiosis that includes the mutual interaction of the technologies of sugar beet processing, bioethanol production, and biopolymer production was designed. The solution, which implies the incorporation of a line for the production of xanthan, a biopolymer of microbial origin with the highest value in the world market, to the already existing facilities for the co-production of sugar and bioethanol, is at the conceptual level and has not been industrialized. The co-production of sugar, bioethanol, and xanthan from sugar beet depends on several factors, i.e. determined ratio of the product quantities, selection of initial raw material for the production of bioethanol and/or xanthan, cost of raw materials and products, etc. The advantage of industrial facilities designed for the proposed co-production is reflected in the fact that co-products or even waste streams of one technology are available at the same point as the complementary raw material in another technology. In this concept, cleaner and more profitable production is contributed by the utilization of thermal energy of waste technological waters, as well as the reduction of energy losses due to shortened transportation of hot fluids from the common power plant to the corresponding points in all three technologies. The reduction in exploitation of water from natural resources for the production media preparation by its substitution with liquid effluents generated in other technologies is also significant from the environmental protection viewpoint. In theory, the concept of co-production of sugar, bioethanol, and xanthan on sugar beet represents an attractive option,

since it allows flexibility in terms of the variation of the produced quantities of individual products, depending on the conditions prevailing on the market.

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Improvement of biodiesel production sustainability through crude glycerol utilization in bioprocesses

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Abstract:

The use of renewable energy sources is a topical global issue. Accordingly, the substitution of liquid fossil fuels with biofuels is increasingly represented. Biofuels production enables the sustainable management of renewable resources and the utilization of biodegradable waste, thus improving safety and reducing the harmful effects of fossil fuels usage on the environment, while economic growth is not endangered. Biodiesel is one of the most commonly used biofuels in the world. However, the intensification of biodiesel production results in the generation of growing amounts of effluents, such as wastewater used to wash the catalyst from the ester phase, unused catalysts, crude glycerol, methanol, soaps, lecithin, proteins, and phospholipids. Crude glycerol is a leading by-product of the biodiesel industry and is generated in the amount of 10% to 20% related to the volume of produced biodiesel. In general, the purity of crude glycerol obtained from the biodiesel industry varies from 38% (w/w) to 96% (w/w). Since the disposal of untreated crude glycerol into the environment is irresponsible and unacceptable, the business of biodiesel manufacturers in the concept of sustainable development requires the implementation of circular economy principles. Therefore, the potential of the biotechnological utilization of crude glycerol for the production of value-added bioproducts was evaluated in this study. The production and application of bioproducts like biopolymers, biosurfactants, and bioagents for crop protection, are more sustainable and ecologically acceptable than their synthetic counterparts. Bioproducts are more efficient under extreme environmental conditions, and exhibit lower ecotoxicity. They are biocompatible and biodegradable and can be modified for specific purposes. The considerations conducted within this study also include an overview of the research stages necessary for the generation of novel bioprocess solutions for crude glycerol utilization in the context of sustainable development and circular economy, as well as the improvement of existing biotechnological capacities. The aforementioned stages are aimed to (I) isolate *de novo* strains, which in industrial conditions produce increased amounts of commercialized bioproducts or biosynthesize unknown metabolites, (II) find low-cost alternative raw materials to minimize over-exploitation of water and other resources, (III) optimize bioprocesses that generate desired bioproducts, and (IV) find new possibilities for the application of bioproducts to protect the environment together with the economic strengthening of all segments of the social community.

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Optimizing Phosphorus Circulation in Organic Waste Management Systems Through the Application of Circular Economy Principles

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Abstract:

The sustainable management of organic waste is increasingly recognized as a critical component of modern agricultural practices and environmental stewardship. This paper explores the circulation of nutrients, specifically phosphorus, within an organic waste management system from the perspective of a circular economy. The aim of the study is to establish a physical and mathematical model that illustrates the pathways of phosphorus through various stages of transformation, from its presence in organic matter to forms that are available to plants. The study focuses on mechanisms that enable the return of phosphorus to the soil through controlled composting processes, ensuring an optimal amount of available phosphorus for agricultural crops while adhering to the principles of a circular economy. The physical model is based on the natural mechanisms of phosphorus circulation, while the mathematical model involves the optimization of composting different organic materials to achieve the desired phosphorus concentration. The paper presents a case study analyzing various phosphorus-rich substrates and their contributions to achieving the optimal phosphorus level for agricultural plants. The optimization covers processes from the collection of organic waste to its treatment and return in the form of compost. The goal is to provide an efficient way to return nutrients to the soil, reducing dependence on mineral fertilizers and supporting sustainable development. The mathematical model predicts different parameters and methods for determining the optimal composition of compost. The focus is on quantifying phosphorus flows and optimizing composting conditions to ensure that plants receive enough of this essential nutrient. This approach aims to create a closed system that efficiently returns phosphorus to the soil, enabling sustainable plant growth and development.

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TOWARDS ZERO WASTE IN THE FOOD PROCESSING INDUSTRY

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Abstract:

Zero waste in fruit processing is essential for reducing environmental impact and maximizing resource efficiency. Over the past 20 years, Serbia has seen an increase to over 30 operational biogas plants. The presented research is a case study of a fruit processing company in Serbia which processes 8,000 t of fruit annually, consuming 2,049 MWh of electricity and 3,936 MWh of heat. The company generates several waste streams: 400 t of fruit pits, 200 t of organic waste from processing (peels, seeds, pulp), 50 t of waste from pipelines of the hot processing facility by pigging, and 30 tons of sludge from wastewater treatment. In total, 280 tons of organic waste are available annually for either biogas or pellet production as part of a biorefinery approach.
A biogas biorefinery CHP system with an installed capacity of 100 kW is recommended based on the waste streams. This system can produce 200 MWh of electricity and 500 MWh of heat annually, covering 10% of the company's electricity consumption and 13% of its heat needs. The specific investment cost for biogas CHP is about €1,500 per kW of installed power, resulting in a total cost of €150,000 for a 100 kW system. The ROI is estimated at 2 to 6 years, depending on performance.
Pellet production from the 280 tons of waste can generate 740 MWh of heat annually based on the calculated boiler efficiency according to the measured emissions, covering 19% of the company's heat demand. A pelletizing system with a capacity of 100-150 kW is recommended, and its specific investment cost is approximately €250 per kW, resulting in a total cost of €25,000. The ROI for pellet production is less than 1 year due to its simplicity and immediate impact on heat savings. Pellet combustion would emit roughly 1,000 kg of CO_2 per MWh, whereas biogas, with its methane capture, could lower emissions to around 200 kg of CO_2 per MWh. With Serbia starting to implement the EU Emission Trading System (ETS), the ROI of the biogas CHP system, would drop to 1.5 to 3 years by additional €42,500 in annual carbon savings, based on the current ETS rate of €85 per ton of CO_2, making the €150,000 investment far more attractive compared to pellet combustion.
The company already uses 400 tons of fruit pits in its biomass boiler, accounting for 42% of total biomass consumption.
This biorefinery approach of combining biogas or pellet production with the existing biomass system could significantly reduce external energy dependence and move the company closer to zero waste, while enhancing energy efficiency and sustainability. Apart from pure technology factors, policy drivers play a key role for decision making.

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Numerical Analysis of the Temperature Distribution in a Pellet Stove as the Generator for an Absorption Heat Pump

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Abstract:

This work presents an initial CFD study on the potential for utilizing biomass pellets in the generator of an absorption heat pump by analyzing the temperature distribution within the biomass furnace. Modern absorption technologies predominantly rely on gas or waste heat as the driving force in the generator, where the two-component working fluid separates into the refrigerant and absorbent. However, very few absorption heat pumps are designed to operate directly with biomass, specifically pellets. In the Balkans, biomass pellets are a widely used and renewable source of thermal energy. The objective of this study is to explore the feasibility of using an absorption generator powered directly by locally available biomass pellets. To support this investigation, the paper provides a thorough overview of current absorption technology and introduces a physical and mathematical model of a small pellet stove in FLUENT, which will be adapted for the generator. Initial simulations yielded temperature fields within the furnace and on its surfaces. The results demonstrated that the temperature field has sufficient potential to initiate the absorption process, with temperatures exceeding 400°C in the upper part of the stove at heating capacities ranging from 13 kW to 20 kW. These findings could serve as a valuable foundation for further design and optimization of absorption heat pump generators for direct biomass utilization in mid-sized systems.

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Exploring Renewable Energy Potential in Serbia: A Focus on Biogas and Combined Heat and Power (CHP) Generation

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Abstract:

Among the key objectives outlined in Serbia's Energy Development Strategy is the exploitation of renewable energy sources, such as biomass, biogas, geothermal, solar, and wind power, while also preserving hydroelectric potential where its utilization is technically feasible and economically viable, particularly in bigger river systems. Current research highlights that Serbia possesses favorable conditions for energy production from renewable sources. In addition to this, the paper provides a comprehensive review of the existing institutional framework governing the renewable energy sector in Serbia, alongside an assessment of the nation’s biogas production potential.
Combined heat and power (CHP) generation is regarded as a highly efficient means of utilizing biogas for energy production. CHP plants, which are capable of achieving efficiencies of up to 90%, typically generate 35% electricity and 65% heat. The deployment of CHP technology presents clear environmental advantages, notably through enhanced energy efficiency and reduced carbon emissions.
This study aims to examine and elucidate Serbia's prospects within the biogas sector, demonstrating the proven biogas potential while emphasizing that the unexploited reserves, when coupled with a well-structured energy sector, could unlock substantial opportunities and foster the development of new market conditions.

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Born: December 11, 1993. A committed research assistant at the University of Niš, specializing in renewable energy with a focus on solar energy and biofuels. With several years of academic and practical experience, Milan is passionate about researching sustainable energy alternatives and improving RES technologies. His work aims to contribute to the global shift toward cleaner energy sources, while actively collaborating with academic peers and industry experts to drive innovative projects forward.

Digital Twins in Biogas Production: Challenges, Technological Potentials, and Key Sensor Parameters

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Abstract:

Digital Twin technology is revolutionizing biogas production by enabling real-time monitoring, simulation, and optimization of plant operations. By integrating advanced sensors with data models, digital twins allow operators to simulate various operational scenarios, optimize key process parameters, and improve decision-making. This technology enhances methane yields, process control, and predictive maintenance, yet faces significant challenges, particularly related to sensor technology, data integration, and computational infrastructure.

One major advantage of digital twins is their ability to optimize anaerobic digestion, which is sensitive to factors like temperature, pH, feedstock composition, and microbial dynamics. Digital twins allow continuous simulation and adjustment of these variables, enhancing efficiency and methane production. Additionally, they improve predictive maintenance by monitoring equipment health and forecasting potential failures, reducing downtime and maintenance costs.

Sensor-related challenges, however, impede implementation. Accurate, real-time data is essential, but many biogas plants lack advanced sensor infrastructure. Harsh operating conditions, including high humidity and corrosive gases, degrade sensors, requiring costly, corrosion-resistant designs. Variability in biological processes and feedstock composition also complicates modeling accuracy, and large data volumes demand robust IT infrastructure, which smaller facilities may lack

Key sensor parameters include temperature, pH, gas composition (CH_4, CO_2, H_2S), feedstock composition, volatile fatty acids (VFAs), and ammonia levels. These factors significantly impact microbial performance and biogas yield. Monitoring and optimizing these variables are critical for maximizing process efficiency.

In conclusion, while digital twins offer significant potential for optimizing biogas production, challenges related to sensor reliability, data integration, and IT infrastructure must be addressed for successful implementation and long-term sustainability.

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Catalysts in Biofuel Production - A Comprehensive Literature Review

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Abstract:

Catalysts play a crucial role in enhancing the efficiency and sustainability of biofuel production, particularly in the conversion of biomass into bioethanol, biodiesel, and biogas. This literature review explores advancements in both heterogeneous and enzymatic catalysts used in biofuel synthesis. Heterogeneous catalysts, such as metal oxides, zeolites, and carbon-based nanomaterials, have shown great promise in improving reaction rates, selectivity, and reducing by-products. The review also delves into the application of enzymatic catalysts like lipases, which offer eco-friendly alternatives for biodiesel production through transesterification.
Recent studies highlight the advantages of nanoparticle-supported catalysts in improving surface area, catalytic activity, and reusability, all of which are critical for scaling up biofuel production. Challenges like catalyst deactivation, metal leaching, and the high cost of catalyst preparation are discussed, along with potential solutions such as the development of bimetallic or hybrid catalysts. The review emphasizes the importance of finding cost-effective and scalable catalytic systems that reduce energy consumption while increasing biofuel yields. Moreover, the impact of catalyst design on the conversion of lignocellulosic biomass into bioethanol is evaluated, considering factors like pretreatment processes, enzymatic hydrolysis, and fermentation efficiency.
This review concludes by identifying future directions for research, including the need for further investigation into catalyst regeneration and the integration of catalytic processes with renewable energy technologies to minimize the carbon footprint of biofuel production. The intersection of chemistry, materials science, and biotechnology presents exciting opportunities for the next generation of biofuel catalysts, potentially revolutionizing the field of sustainable energy.

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Modelling of Integrated Biorefinery for Municipal Solid Waste

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Abstract:

The inefficient waste management system presents several issues, including negative impacts on human health, environmental contamination, resource depletion, and loss of potential. Based on data on the characteristics and composition of municipal solid waste and considering waste conversion technologies, a combination of anaerobic digestion and fermentation for organic waste, incineration for mixed waste, and landfilling for unused remains and residues offers a possible solution for improved waste management and transition toward a circular economy. Therefore, this research aimed to provide a simulation solution for integrated biorefinery based on municipal solid waste using SuperPro Designer software. The developed model's prerequisite is that collected municipal waste must be separated into recyclable and non-recyclable fractions. The non-recyclable part of the waste should be sorted into organics and mixed waste. Prevailing organics waste fraction, consisting of food, kitchen, and garden waste, can be processed by anaerobic digestion and fermentation with biogas and bioethanol production, respectively. Mixed inorganics and the remains of the organics go to incineration with heat and electricity generation. Thus, depending on the applied technology, the waste conversion products are bioethanol, biogas, electricity, heat, and valuable materials that can be further used for activities in which waste was primarily generated. Selecting suitable technology for waste treatment requires a comprehensive analysis of the entire technological process and the prediction of many scenarios, including economic and environmental factors. The modelling of integrated processes for waste valorisation will generate data that could be used for further development of this biorefinery and consequently of assistance to decision-makers who are confronted with difficulties related to waste management.

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Reduction of iron ore: an effective strategy for decarbonization of heavy industry and H_2 transport

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Abstract:

Iron ores are natural minerals largely available on earth. Reduction/oxidation of iron minerals have been so far investigated in the context of steel making and over the last decade also in chemical looping combustion and gasification. Further applications are foreseen for iron minerals, such as in the development of cheap solid hydrogen carriers, in decarbonizing steel industry, and in developing functionalized iron-based materials for CO_2 capture. The present work presents recent studies carried out at STEMS-CNR on reduction of iron ores with either H_2 or biomass. A first project aimed to formulate comprehensive kinetic models for iron ore reduction and reoxidation, to be used in H_2 storage cycles. A second path aims to clarify if biomass is able to reduce natural hematite (Fe_2O_3) to metallic iron (Direct Reduction Iron, DRI), with the advantages of low ash production and high reactivity. Along the first path, thermochemical reactions of a natural Fe_2O_3, Khumani iron ore (KIO), are investigated in a thermogravimetric apparatus upon heating up to 1000°C in H_2 enriched atmospheres. Along the second path, mixtures of KIO and lignocellulosic biomasses are treated in the same apparatus in an inert atmosphere with different biomass to iron ore ratios.
The main gaseous products have been monitored online by gas analysers, while the physicochemical properties and structure of the solid products have been characterized by X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM).
Results indicate the existence of synergies between biomass and iron ore reduction, in particular, the products of biomass pyrolysis act as reducing agents for iron ore and are capable to progressively reduce Fe_2O_3 to Fe_3O_4, wüstite and iron even in inert atmospheres. Complete reduction of Fe_2O_3 to iron has been achieved at 1000°C (3-1 BIOMASS-KIO wt%). The same degree of reduction can be attained with KIO in H_2/N_2 mixtures at 900°C.
Results suggest that the fabrication of advanced materials, iron functionalized with biomass, has potential applications in the fast-growing field of environmental green ironmaking technologies. Further work will be carried out to investigate also the potential of this approach for tailoring carbonaceous chars for catalysis and environmental applications.

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Optimization of Solids for Enhanced Biogas Recovery from Poultry Waste during Anaerobic Digestion

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Abstract:

As fossil energy resources will eventually run out; recent studies have been focusing on clean alternative sources like biogas through anaerobic digestion (AD) which has been the main use of biomass-based renewable energy. Besides, AD has also a crucial role on the valorization of feedstocks for organic fertilizer nutrients production in conjunction with the circular economy. AD with total solids (TS) content in the raw materials below 10%, between 10% and 15%, and above 15% are categorized as the wet, semi-dry, and dry processes, respectively; which offer several benefits and drawbacks. Here, poultry manure is a suitable feedstock with a substantial biomethane potential due to its rich TS content and high biodegradability. However, high TS content could hinder biomethanation during AD as well as the presence of ammonia and volatile fatty acids (VFAs) might negatively affect anaerobic microorganisms. Hence, initial TS content should be optimized in order to overcome such limitations and to enhance biogas production during AD. This study aims to identify the optimal conditions with respect to TS content for generating the maximal biogas from chicken manure in 1-L lab-scale batch bioreactors operated at different initial TS concentrations. Raw chicken waste which was collected from a poultry farm approximately 80 km west of Istanbul Technical University, was the manure of only the laying-hen livestock. The inoculum was obtained from an industrial (i.e., paper/cardboard industry) wastewater treatment plant's anaerobic digestion unit (Istanbul – Turkey). The total solids and the volatile solids-to-total solids ratio of chicken waste was about 28% and 56%, respectively. However, anaerobic bioreactors were fed with this chicken waste after diluted with tap water in order to obtain the initial TS ratios between 3.4% - 11.5%. The reactors were incubated at dark and at mesophilic temperature (35±2◦C) with a retention time of about 60 days. The flasks were mixed twice a day in order to provide the effective contact of the seed and the substrate. The produced biogas at the headspaces of the reactors was measured by a manometer and then released by injection needles. While the findings of this study indicated that chicken waste could be digested effectively even at high TS contents; the maximum biogas yields were found in the reactors with 3.4% and 5.6% TS ratios as about 250 and 240 mL/g VS, respectively. Hence, the results showed that a TS ratio below 6.0% was associated with the most accumulative production at wet AD condition, followed by TS=7.5%. On the other hand, the lowest biogas yield was associated with TS=11.5% with about 170 mL/g VS which indicated about 30% reduction during biochemical conversions of organic matter to methane and carbon dioxide at semi-dry condition. These experimental findings were supported by theoretical results and it could be concluded that initial solids concentration was one of the effective parameters for biogas production from poultry manure.

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Ni-Ru over $LaMnO_3$ for syngas production via chemical looping reforming (CLR) of CH_4

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Abstract:

Methane chemical looping reforming (CLR) is a useful method for syngas production. Ni catalysts over oxides with good redox properties, such as $LaMnO_3$, are promising for chemical looping reforming reactions. Moreover, the addition of Ru is known to stabilize Ni nanoparticles against sintering and to minimize coke deposition. On this basis, Ni and Ni-Ru over $LaMnO_3$ were chosen as good candidate for CLR. The preparation methods of the oxygen carrier oxide may strongly influence the structure, redox properties, metal-support interaction of the corresponding metal supported catalysts, thereby affecting their catalytic properties. This study examines the performance of Ni (10wt%) and Ni(10wt%)-Ru(1wt%) catalysts supported on $LaMnO_3$ synthesized through precipitation assisted by microwave irradiation and sol-gel citrate methods. The CH_4 CLR tests were performed carrying out multiple cycles, consisting in methane partial oxidation by the carrier oxide and the concomitant decomposition to H_2 occurring over metallic Ni, formed in situ, and successive regeneration of the catalyst under CO_2, aiming to reoxidize the sample and remove the deposited carbon coke. The experiments were realized alternating the gas composition every 10 minutes between 15 vol% CH_4 in N_2 (reduction) and 15 vol% CO_2 in N_2 (oxidation) at isothermal conditions. The reaction temperature for each sample was determined by performing temperature programmed reduction tests with methane, selecting the temperature of maximum reduction for each sample. By conducting comprehensive structural and morphological analyses and catalytic tests, this study highlights the impact of synthesis techniques on the performance of these samples in hydrogen production and provides valuable insights crucial for developing new efficient catalysts.

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Wheat straw lignin as active filler in thermoplastic starch packaging

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Abstract:

Lignin is an interesting candidate as an additive in biopolymer composites in order to confer anti-oxidant, UV-shielding, and antimicrobial properties in packaging films made from biopolymers such as thermoplastic starch (TPS). As the second most abundant biopolymer after cellulose, lignin is produced as a side stream in biorefineries or the pulp and paper industry in vast amounts. In contrast to lignin deriving from wood, lignin from herbaceous biomass such as wheat straw is characterized by additional structural features like p-hydroxycinnamic acids, which can be present either incorporated into the lignin macromolecule or as pendant groups on lignin side-chains. These structural features could promote interactions between the active filler and the biopolymer matrix during film formation providing improved thermal and mechanical properties.

Two different non-wood lignins were utilized as active fillers in TPS films. Organosolv wheat straw lignin was prepared using ethanol-water for Organosolv extraction and separated by precipitation after evaporation of ethanol, followed by repeated washing with acidified water (pH 2), centrifugation and freeze-drying. For comparison, commercially available wheat straw lignin from alkaline pulping (Protobind 1000, PLT Innovations AG, Rüschlikon, Switzerland) was used. Biocomposite films were realized by using a twin-screw microextruder (DSM Xplore 5&15 CC Micro Compounder/Film Device). During the mixing/plasticization, the screw speed was set at 60 rpm, with a temperature profile of 135-140-145 °C for 180 s.

The wheat starch matrix was amended with lignin nanoparticles before mixing with glycerol and eventual film extrusion. SEM analysis showed two distinct particle size fractions of wheat starch granules. Wheat starch granules were covered and held together by phases of agglomerated lignin nanoparticles. Extruded films were analysed regarding their UV-light blocking capacity, antioxidant activity and their degradation behaviour in composting conditions. Mechanical properties were investigated using tensile tests.

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Florian Zikeli has been working with lignocellulosics since his PhD thesis in 2010, which he conducted both at TU Wien and at 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. Since, 2024, he holds a non tenure track assistant professor position (Italian RTDa) at University of Perugia.

The Refinery of the Future – What will it take?

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Abstract:

The current addiction to fossil fuels and fossil materials will have to end soon. Our need for energy and a wide variety of materials will not. Although still mainly wishful thinking, we propose to think about what we call 'the refinery of the future', a way to make materials and chemicals based on renewable and sustainable feeds and electricity. Recycling will only solve half the problem; biomass and captured carbon will be needed to form the basis of material feedstocks.
While the technologies will likely be different from today, there are also important decisions related to novel supply chains, environmental and social impact, and company structure. Many have argued that shareholder capitalism is a major reason for the unchecked pollution and exhaustion of the natural world in the 20th and 21st century by large corporates. Providing for society's material needs will need to avoid falling into these same traps as the industry changes. Likewise, shifting the source of carbon must not simply shift environmental and social issues onto the biomass sector.
The biobased transitions team attempts to envision the refinery of the future and answer open-ended questions surrounding it. What types of companies created the refinery, did they begin as start-ups or transition from fossil companies? How is biomass procured, and where is the value controlled in the supply chain? What regulatory support got us here, and what other industries are involved? These non-technical aspects of biorefining may have large implications in the shape the transition takes, and in answering them we hope to guide policy and stakeholders towards robust and resilient pathways.

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Innovative Industrial Heating: Integrating Renewable Gases and Hybrid Solutions

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Abstract:

The industrial sector significantly contributes to global carbon emissions due to its heavy reliance on fossil fuels for heating processes. To combat climate change and facilitate the transition to cleaner energy sources, the exploration of alternative fuels is essential. Highlighting the potential of renewable hydrogen and biogas, as well as hybrid applications combining these with electricity, offers sustainable solutions for industrial heating applications.
Renewable hydrogen, produced via water electrolysis powered by renewable energy sources such as wind, solar, or hydro power, presents a carbon-neutral alternative to conventional hydrogen production methods, which often rely on fossil fuels. The combustion of hydrogen-oxygen is particularly advantageous in high-temperature industrial processes, as it only produces water vapor as a byproduct, completely eliminating carbon emissions. The use of hydrogen-oxygen mixtures can enhance energy efficiency and provide cleaner combustion compared to traditional fuels.
Biogas, derived from organic waste through anaerobic digestion, represents another viable alternative. Composed mainly of methane, biogas can be purified and utilized similarly to natural gas in various industrial heating applications. This not only reduces dependence on fossil fuels but also offers a productive use of organic waste, contributing to a circular economy. By upgrading biogas to biomethane, it can be injected into existing natural gas networks or directly used in industrial processes, providing flexibility and sustainability.
In the realm of industrial heating, renewable hydrogen and biogas serve as clean and efficient energy carriers. The high energy density and clean combustion properties of renewable hydrogen, combined with the renewable nature and lower carbon emissions of biogas, make them suitable for various heating processes such as furnaces, kilns, and boilers. Integrating these renewable fuels into industrial heating systems can significantly reduce the carbon footprint of businesses while ensuring process efficiency and reliability.
The benefits of renewable hydrogen and biogas include ecological advantages, potential long-term cost savings, and compatibility with existing infrastructure. For instance, renewable hydrogen can be blended with natural gas to gradually decarbonize existing systems, while biogas can be utilized in regions where organic waste is readily available. Both fuels can be connected to existing pipeline and storage infrastructures with minimal modifications, facilitating their adoption. Furthermore, the discussion addresses the challenges and opportunities associated with the implementation of renewable hydrogen, biogas and electric energy in industrial settings. Efficient storage and distribution solutions are crucial, as the low energy density of hydrogen per volume requires innovative storage solutions, and biogas necessitates purification and consistent supply

chains. Developing robust infrastructure and supportive policies will be critical to overcoming these challenges.

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N-rich carbonaceous adsorbents from agricultural and marine biomass residues for CO_2 capture and gas storage

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Abstract:

Porous carbons are widely used as CO_2 adsorbents and the research of strategies for materials synthesis and optimization has developed tremendously in the last decade. Carbon-based adsorbents have many advantages over non-carbonaceous materials: they are chemically and thermally stable, they are characterized by very high pore volumes and specific surface areas, they have high adsorption capacity and outstanding cycling performances, they can be easily produced by combined pyrolysis/activation process, and they can be easily regenerated. Moreover, their native hydrophobic nature (occurring in most cases) leads to their adsorption efficiency in the gas phase not being affected by the presence of moisture. Finally, another aspect of interest is that the carbonaceous adsorbent surface is prone to be modified through the incorporation of different functional groups. Carbon-rich materials adsorbents derived from biomass residues have been largely tested for the sequestration of different types of pollutants in water streams (dyes, heavy metals, crude oil components) and their use also as solid sorbents for CO_2 capture application is continuously increasing. In this framework, N-doped porous carbons have garnered much attention due to the ease of preparation and the good performances due to the presence of basic nitrogen-containing groups able to interact favourably with acidic CO_2 molecules. In this work we have prepared N-rich carbonaceous materials from agricultural and marine biomass residues, and we have performed gas adsorption tests to evaluate the CO_2 uptake, the CO_2/CH_4 selectivity and the capacity to store H_2. The carbonaceous materials were produced starting from residues characterized by a high N content: thistle (Cirsium vulgare), chitosan obtained from the chitin of crustacean shells, and lemon peel recovered as waste after the Limoncello liquor production process. All the materials, obtained by carbonizing the biomass residues at 550°C under nitrogen atmosphere, underwent a deep chemico-physical characterization and were tested in a volumetric analyser at different temperature and pressure values. The relationship between the chemico-physical characteristics of N-rich char samples and the gas uptakes and selectivity was evaluated and discussed.

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Details of presenting author

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Short biography: Luciana Cimino holds a full degree in Chemistry (2009) and she has been working at National Research Council of Italy (CNR) since 2023. Her laboratory activities deal with the characterization and the treatment of carbon-rich matrices (biomass, wastes, liquid fuels) and products of thermoconversion processes, the synthesis and the characterization of advanced materials and the chemico-physical analysis of complex carbonaceous materials. She is experienced in the use of different analytical techniques (chromatography (LC, GCMS), thermogravimetry, elemental analysis, spectroscopy (FTIR, UV-vis), volumetric adsorption methods and different synthetic approaches.

Enhanced Thermal and Photothermal Catalytic Performance in Dry Reforming Using Ni-based Catalysts

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Abstract:

Nowadays, escalating environmental challenges such as pollution, desertification, and climate change, induced by human activities, have become prominent problems. The massive combustion of fossil fuels has led to a significant release of carbon dioxide (CO_2) into the atmosphere, while methane (CH_4), another dangerous greenhouse gas emitted from various sources, has further intensified the impact of global warming. To address these issues, CO_2 reforming has emerged as a promising solution, converting CO_2 and CH_4 into syngas (H_2 + CO). In this context, cutting-edge technologies like thermocatalytic reforming and the newer photothermo-catalytic reforming have garnered significant attention. Solar-assisted thermocatalysis is particularly interesting because it utilizes sunlight to produce syngas from CO_2 and CH_4, offering a sustainable energy solution. Moreover, the integration of these processes is required in order to enhance the overall efficiency, particularly in the hydrogen production. This study investigates the performance of nickel (Ni) catalysts supported on ceria (CeO_2) and ceria-zirconia (CeO_2-ZrO_2). The Ni/CeO_2 and Ni/CeO_2-ZrO_2 catalysts were synthesized using two different methods, the sol-gel citrate (SG) and the hydrothermal method (HT). Thermocatalytic experiments were conducted in a fixed-bed flow reactor, the feed gas, consisting of CH_4 and CO_2 in He, was led over the catalyst (100 mg) at 750 °C. Photo-assisted CO_2 thermocatalytic reforming tests were performed using the same gases stream, irradiating with a solar lamp for 5 h at 500°C. Before thermo and photothermo catalytic tests the samples were reduced under flowing 5% H_2/Ar at 750 °C for 1h. CO_2 and CH_4 conversion, determined by GC-TCD measurements. To evaluate the influence of different preparation methods on their textural, morphological, catalytic, and photothermo-catalytic properties, the catalysts were analyzed using a range of techniques, including N_2 adsorption–desorption measurements, XRD, Raman spectroscopy, SEM, UV–vis DRS, TPR, and CO_2-TPD. From the preliminary catalytic screening, the HT series proved to be more active in thermocatalytic dry reforming and in the photothermocatalytic approach. Other tests are undergoing to correlate the properties of the examined catalysts with their catalytic and photothermo-catalytic activities.

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Short biography**:** Eleonora La Greca graduated in Industrial Chemistry at the University of Catania and attained the master's degree in Chemical Sciences in the same University. She was a research fellow at CNR-ISMN of Palermo for two years, under the supervision of Dr. Leonarda Francesca Liotta. In 2023 she began the Italian national PhD in Catalysis with a project about the H_2 production and the subsequent CO_2 valorisation. This highly qualifying PhD program is enabling her to deepen its knowledge and skills in the field of catalysis, one of the most crucial areas in both industrial chemistry and scientific research.

Hydrogen Production from Plastic Waste via Pyrolysis: Economic Prospects with Carbon Storage Incentives

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Abstract:

The global plastic waste crisis and the urgent need for clean energy have prompted the exploration of innovative solutions such as pyrolysis. Pyrolysis, a thermochemical process that breaks down organic matter in an oxygen-deprived environment, offers significant potential for converting plastic waste into valuable products, including hydrogen, syngas and char. This approach not only solves the urgent problem of waste management, but also contributes to the development of the hydrogen economy. A novel aspect of this technology is the potential for carbon storage, where the carbon contained in plastic waste is sequestered rather than released, offering additional environmental and economic benefits.

At present, the technology for producing hydrogen from plastic waste by pyrolysis is still under development, but it is very promising. The economic viability of the process depends on overcoming several challenges, such as high energy requirements, the variability of plastic waste streams and the need to purify the hydrogen. Managing the carbon content, particularly of the charcoal produced during pyrolysis, is both a challenge and an opportunity. Traditionally, this coal is burnt to recover energy, releasing CO_2, but another approach is to store and use the carbon in various forms (for example, for tires, activated carbon), thereby contributing to carbon sequestration efforts.

The economic feasibility of producing hydrogen from plastic waste by pyrolysis depends on factors such as the costs of collecting the plastic waste, pre-treatment and the energy-intensive nature of the pyrolysis process. The capital expenditure (CAPEX) for setting up a pyrolysis plant including hydrogen production is estimated at between $3,000 and $6,000 per 1,000 tonnes of treatment capacity, with operating costs (OPEX) determined by the energy requirements of the process. Currently, the cost of producing hydrogen using this method is estimated at between $3 and $7 per kilogram, which is higher than conventional methods such as natural gas reforming, which typically costs $1 to $2 per kilogram.

Current demonstration projects for the pyrolysis of plastics involve very large-scale facilities with a waste treatment capacity of over 100,000 tonnes/year, which implies complex and costly collection and storage logistics. However, in Europe, the average plastics recycling plant processes around 15,000 tonnes of plastic per year, a size that would be more appropriate for hydrogen production (around 1,500 tonnes/year), which corresponds to small-scale plants producing H_2 by electrolysis.

Carbon storage credits could have a significant impact on the economics of pyrolysis, potentially reducing the net cost of hydrogen production. Depending on market conditions, these credits could range from $20 to $100 per tonne of stored CO_2 equivalent, reducing hydrogen production costs by around $0.50 to $1.00 per kilogram, making it more competitive with traditional methods.

As research progresses, this technology could become a key player in the hydrogen economy, offering a sustainable and economically viable alternative to conventional methods. The dual benefits of waste reduction and carbon sequestration make this technology an essential component of future sustainable energy systems.

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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.

A reduced kinetic model for the oxidation of SAF components

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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. To achieve sustainable and green aviation through SAFs, understanding their fundamental oxidation properties and developing reliable kinetic mechanisms are essential prerequisites to guarantee the development of aircraft engines and the improvement of aeronautical propulsion systems. Besides, the large number of species and reactions typically included in detailed kinetic mechanisms result in various modes and time scales, which make the computation of complex combustion phenomena untenable. Therefore reduced kinetic models are required for high computational cost simulations (i.e. turbulent flames). Given this framework, the present work aims at developing a reduced kinetic mechanism for SAF oxidation through the sequential application of different reduction techniques. First, a detailed database has been collected, performing experimental tests in Jet Stirred Reactors (JSRs) on the oxidation of different hydrocarbons representative of each class of SAF components (linear, branched, aromatic hydrocarbons), at different operating conditions.
Then, the collected data were simulated with various kinetic mechanisms available in the literature to identify the most reliable master mechanism for the reduction.
Among the considered schemes, the Polimi Kerosene HT (121 species, 2613 reactions) was identified as the optimal trade-off between the number of species/reaction and modeling accuracy. The mechanism reduction was performed with the Reaction Workbench of Ansys. The target parameters for comparison between the master mechanism and the reduced one are the temperature, the stable measured species (O_2, CH_4, H_2, CO) and the radicals OH, H, HO_2. A skeletal mechanism was obtained by a sequential use of different Direct Relation Graph (DRG) techniques, in particular DRG, DRGASA (Direct Relation Graph Aimed at Sensitivity Analysis) and flux-based DRG. As a further step, the model will be tested and optimized against experimental data on different mixtures of SAF surrogates.

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Short biography: I got my PhD in 2022 at University of Napoli Federico II. I am currently researcher at Institute STEMS-CNR of Napoli. I graduated in Chemical Engineering at University of Napoli Federico II. I'm currently working on oxidation of non-conventional fuels for the decarbonization of energy carriers, such as hydrogen, ammonia and sustainable aviation fuels, publishing the most relevant results in renowned journals in the field.

Solar-assisted HTL Developmental Path at CERTH

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Abstract:

Hydrothermal liquefaction (HTL) is a thermochemical technology converting different types of highly moist biomass into a main product and three byproducts, namely: a biocrude oil (main product), a liquid phase rich in phosphates/nitrates, a solid biochar (depending on the parameters and the feedstock), and a gaseous phase comprising mainly CH_4, CO and CO_2. Although the technology made its debut half a century ago following the 1973 Oil Crisis, it was only during the last decade that it attracted renewed research interest, which was mainly attributed to the fossil fuels depletion, the biomass excess and the ever-worsening climate crisis. HTL favors wet biomass, as water in the area of its sub-/super- critical conditions (374ºC, 221 bar) acts at the same time as reactant, solvent and catalyst due to the change of its dielectric and ionization constants, leading to the enhancement of the reaction efficiency. The favourable conditions of HTL are applied within the range of 250-550ºC and 5-25 MPa, which are ideal conditions for the introduction of concentrated solar thermal (CST) technologies as the heating means of the process. This study presents the work carried out at CERTH, starting from the conventional (electrical) heating of the HTL process (lab-scale) and expanding up to the on-field, solar testing (semi-pilot scale). In the case of the semi-pilot scale, an automated, mobile setup is used as the platform where the parabolic trough collectors are installed and able to operate in the range of 350ºC. Artificial light in CERTH's in-house solar simulator is given as an intermediate step between lab and on-field testing. As a given example, the results of selected essential oils waste tested at different conditions will be provided as a comparative means between conventional heating and heating provided by CST technologies. An improvement of the biocrude yield is observed when concentrated solar thermal technologies are introduced, which is largely attributed to the faster heating/cooling rates achieved.

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Production of High Value Added Products from Agricultural Wastes: Circular Bioeconomy Perspective

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Abstract:

Agricultural waste consists of plant and animal origin from various agricultural activities. Agricultural wastes typically consist of by-products with varying compositions, depending on the products generated during processing. Their rich nutritional content in various concentrations makes them suitable for use in sustainable solutions. As the global human population and food demand rise, the agricultural industry continues to grow, leading to a corresponding increase in agricultural waste. A circular economy seeks to minimize waste and enhance resource efficiency by promoting practices such as recycling, reusing, and regenerating materials. This approach turns the waste from one process into a valuable input for others, thereby erasing the idea of waste entirely. Agricultural waste and the circular economy are closely linked, both playing a key role in advancing sustainability in agriculture. Producing value-added products from agricultural waste supports the circular economy, reducing waste and contributing to sustainable agricultural practices. In this process, products such as biofuel, fertilizer, and bioplastic are obtained, creating economic value and encouraging environmental sustainability. The bioeconomy refers to an economic system that uses renewable biological resources to produce a wide range of products and services. Covering industries like agriculture, forestry, fisheries, and biotechnology, the bioeconomy leverages cutting-edge technologies to produce a wide array of products, including biofuels, biomaterials, and biopharmaceuticals. Bioeconomy can play an important role in combating climate change by reducing dependence on fossil fuels through the use of renewable biological resources. Governments and various institutions are investing in the development of bioeconomy and producing policies that encourage sustainable practices. In this context, bioeconomy emerges as a promising model that reduces waste, uses resources more efficiently and supports the transition to a circular economy.

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Short biography**:** I work at Giresun University Technology Transfer Office. I provide support to academics and entrepreneurs, especially start-ups, on issues such as university-industry collaboration, finding funding sources and protecting intellectual property rights. I have a PhD in enzyme and microbial biotechnology. I am also an agricultural engineer.

Understanding the fate of carbon, nutrient and pollutants to propose typology of organic sludge fertilizers

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Abstract:

The objective of this study is to propose a new typology of organic sludge fertilizers. It is part of the MSCA EU Project INCLUE (https://inclue.eu) whose ambition is to develop innovative and circular solutions to combine pollutants removal in sludge from wastewater with maximum resource recovery. The INCLUE project is an international, intersectoral and interdisciplinary research training program in the field of sludge pre-treatment combined with advanced bioconversion techniques and multi-level toxicity assessment. The main objective of such treatment combination is to achieve an **effective abatement and/or recovery of both hazardous and valuable compounds** from municipal and industrial sludge.

The aim of the INCLUE project is to go beyond the state of the art of sludge treatment technologies in diverse concerns, specifically:

- developing **intensified sludge treatment techniques**, i.e. ultrasound pre-cracking combined with supercritical water oxidation, microwave based hydrothermal carbonization (HTC), electrochemical pre-treatment for heavy metal removal and pathogen inactivation;
- developing **augmented sludge fermentation processes** i.e. stress-induced fermentation, anaerobic digestion set-up for improved bioplastic degradation, engineered nanomaterials for improved performances of anaerobic communities;
- introducing an **eco-impact assessment strategy** to predict the effect on the ecosystem through development of rapid biosensors for complex matrices, eco-toxic assessment methodologies with whole vertebrate organism and modeling the fate of organic pollutants and of nutrient supply to soil for plant growth.

The topic of this thesis, in the frame of the eco-impact assessment strategy, is to **characterize the effectiveness of various treatments on the quality and innocuousness as fertilizers of treated sludge, digestate and char-based materials through a multi-criteria analysis**. First, the stability of the organic matter, the fate of nutrients (carbon, nitrogen and phosphorous) and of the remaining organic pollutants will be investigated through an in-house developed biochemical extraction technique. The aim is to define and develop indicators, related to the quality of the fertilizer, to be included in the final multi-criteria analysis. Statistical analysis will be applied to build a methodology to evaluate the impact of several types of treatment technologies and the suitability of the final fertilizer product with specific agroecosystem needs. The final outcome will be the design of a multi-criteria analysis tool, based on indicators relying on characterization data and data collected from the other partners of the project, capable of supporting decision making on treatment and application of sludge fertilizers, and to assess the overall environmental impact.

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Short biography**:** I achieved my Master Degree in Industrial Biotechnology at University of Bologna in March 2019. I carried out research activities in Italy and abroad regarding the improvement of the anaerobic digestion process and biomass pre-treatment at Centro de Engenharia Biológica (PT) and at Instituto de la Grasa (ES). I have been working at CRPA, a research centre in Reggio Emilia (IT), from 2019 to 2023, on projects regarding anaerobic digestion optimization and its integration in biorefineries, and as consultant for biogas/biomethane plants. In March 2024 I started my PhD project at INRAE-LBE (FR) in bioprocess engineering on renewable sludge-based fertilizers.

Production and applications of waste-derived biochar

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Abstract:

The global push towards sustainable waste management and a circular economy has driven significant interest in converting waste materials into valuable products. Biochar, a carbon-rich material derived from the thermal decomposition of organic waste, emerges as a promising solution in this context. This study examines the production of biochar from various waste sources, including agricultural residues, municipal solid waste, and industrial by-products, and explores its broad applications in environmental remediation, soil enhancement, and carbon sequestration.

Our research focuses on understanding how different production conditions influence the properties of the resulting biochar. By adjusting key parameters during the thermal conversion process, we aim to tailor the characteristics of biochar to meet specific application needs. The study highlights the importance of optimizing these conditions to maximize the functional benefits of biochar.

We also assess the potential of waste-derived biochar in several practical applications. In agriculture, biochar is shown to improve soil quality, enhance water retention, and boost crop productivity, while also contributing to the reduction of greenhouse gas emissions. In the field of environmental remediation, biochar demonstrates its effectiveness as an adsorbent for pollutants, making it a valuable tool for cleaning up contaminated environments. Moreover, the role of biochar in carbon sequestration is discussed, emphasizing its capacity to lock carbon in a stable form, thereby contributing to climate change mitigation.

This research highlights the versatility and environmental benefits of using waste-derived biochar, promoting its role in sustainable waste management practices. The findings offer valuable insights for researchers, policymakers, and industry stakeholders interested in advancing the circular economy and fostering environmental sustainability.

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Short biography**:** Prof. Ondřej Mašek, Chair of Net Zero Emission Technologies at the University of Edinburgh, leads the UK Biochar Research Centre (UKBRC) in advancing biochar production and application. With 18 years of experience, he specializes in converting biomass into sustainable products for carbon sequestration and climate change mitigation. Prof. Mašek has authored over 170 peer-reviewed publications and is a highly-cited researcher. He collaborates globally, with projects exceeding £20 million. His work focuses on engineered biochar, enhancing environmental and economic benefits while addressing climate change and promoting sustainability.

Synthesis of Nitrogen-Doped Biomass-Based Activated Carbon Catalysts with Co and Cu for Hydrazine Oxidation

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Abstract:

Biomass-derived carbons have gained attention as viable alternatives to traditional carbon-based catalysts. These materials are highly promising as renewable sources for sustainable carbon applications in future energy storage and conversion technologies. Biomass stands out as an attractive carbon precursor due to its renewable nature, abundance, environmental friendliness, low cost, non-toxicity, sustainability, straightforward production process, and inherent variety of heteroatoms (such as N, P, S, etc.). In this study, we introduce a straightforward approach for the synthesis of an effective non-noble metal-based carbon catalyst. First, a biomass-based activated carbon material (AWC) was synthesized using a birch wood as the raw material. Cobalt (Co) or copper (Cu) and nitrogen were co-doped in a single step using a reaction mixture containing 10% Co^{2+} or Cu^{2+} ions relative to AWC, along with dicyandiamide (DCDA) in dimethylformamide (DMF). After evaporation of the DMF, the mixture was treated at 800 °C for 60 minutes. A comprehensive physicochemical characterization of the newly synthesized catalyst was performed using ICP-OES, XRD, XPS, SEM-EDS, TEM, BET surface area analysis, and Raman spectroscopy. The synthesized AWC-Co-N catalyst was found to contain approximately 1.29 at.% Co and 98.71 at.% C, while the AWC-Cu-N catalyst contained about 1.19 at.% Cu and 98.81 at.% C. The electrocatalytic activity of the AWC-Co-N and AWC-Cu-N catalysts for the electrooxidation of hydrazine (N_2H_4) was assessed using cyclic voltammetry by recording cyclic voltammograms in a 1 M KOH solution with varying concentrations of N_2H_4 over a potential range from -1.2 V to 0.2 V (vs. SCE) at a scan rate of 50 mV s^{-1}. Both AWC-Co-N and AWC-Cu-N catalysts demonstrated excellent activity and stability for N_2H_4 electrooxidation, indicating their potential as promising anode catalysts for direct hydrazine fuel cells (DHFCs).

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Nickel catalysts supported on SiO_2-CeO_2 mixed oxides for methane dry reforming

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Abstract:

Syngas, a gas mixture in which H_2 and CO are the main products, is a potential industrial feedstock for the catalytic synthesis of chemicals, biofuel, power generation, and heating. Moreover, hydrogen from syngas finds applications as building block for the design of fuel cells and NH_3 production, among others.
In this work, we developed nickel-based catalysts to produce syngas from methane reforming by carbon dioxide. Heterogeneous supports were prepared with the aim to obtain a catalytic platform able to stabilize Ni metal species as dispersed nanoparticles with a better resistance to coke formation in high-temperature reforming processes.
A series of SiO_2-CeO_2 mixed oxides has been prepared via a sol-gel procedure from tetraethyl orthosilicate and cerium(III) nitrate as synthetic precursors. In order to study the role of the catalytic support, the composition of SiO_2-CeO_2 solids has been tailored by synthesizing four materials with ceria content ranging from 5 to 30 wt.%. The wetness impregnation method over SiO_2-CeO_2 materials was employed to modify the solids with nickel catalytic sites. The obtained catalysts were characterized by X-ray powder diffraction (XRD), N_2 physisorption, and temperature-programmed reduction (TPR). All the catalytic tests were carried out after reducing the catalyst in a flow of an H_2-He mixture, whereas methane dry reforming was performed by using a gas mixture of 15 vol % CH_4 and 15 vol % CO_2 in helium. The effect of temperature on the catalytic performance was examined using stepwise heating in the range 450–800°C. Thermogravimetric (TG) and XRD analyses were performed on spent samples in order to evaluate the formation of carbon deposits and the evolution of the catalysts crystalline phases during the tests.

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Short biography: Carla Calabrese received her Ph.D. in Chemistry from the University of Palermo and the University of Namur in 2019 and she was awarded for the best Ph.D. thesis in Green Chemistry from the Italian Chemical Society. She was postdoctoral researcher at the University of Palermo (2019-2021) and at the National Council of Research (2021-2022). From April 2022, she worked as Chemical Customs Officer at the Italian Customs and Monopoly Agency. From May 2024, she is permanent researcher at the CNR-ISMN of Palermo. Her research interests cover heterogeneous catalysis for environmental applications in conjunction with the development of hybrid nanostructured materials.

Utilization of carbon dioxide by bacteria for sustainable biorefinery products

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Abstract:

Population and industrialization cause energy demand to increase rapidly. Environmental problems such as depletion of fossil fuel reserves, global warming, greenhouse gas emissions, and acid rain have led to usage of sustainable alternative energy sources. Biofuels have significant potential among renewable and sustainable energy sources. The use of agricultural products for energy production causes the reduction of planting areas and biodiversity, damage to the food chain, and an increase in the price of food products, and also fails to provide a significant reduction in greenhouse gas emissions. Additionally, technological and cost-related problems that are still unsolved in the production of second generation biofuel constitute an obstacle to the widespread use of these processes in industrial terms. These obstacles can be overcome by developing biorefinery processes that include integrated systems and that the development and implementation of these processes are very important for sustainable economies based on biotechnology. Although there are microbial cells developed in this area, there is no high yield strain. In order to fill this gap, this work aims to find strategies to design/engineer *E. coli* strains that will achieve high CO_2 fixation in sustainable production of biorefinery products. Here, thermodynamic bottlenecks in the carbon metabolism of *Escherichia coli* are identified to investigate CO_2 fixation capacity of this microorganism. High value-added chemicals whilst using CO_2 in microbial fermentation are categorized according to the thermodynamic capacity of the metabolic pathway that they are part of. Pathways that include the bottleneck reactions among the elementary modes will be created and the cellular Gibbs energy dissipation rate will be calculated for each pathway. The pathways will be ranked according to their values, thus, the pathways that can reach CO_2 fixation among the thermodynamically possible pathways will be determined. These pathways will constitute the production platform for biorefinery products.

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Simulation and optimization of bio-oil, biochar, and syngas obtained from the co-pyrolysis of date seeds and tire plastic waste

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Abstract:

In this study date seeds and tire plastic waste were used to model and simulate a co-pyrolysis process in Aspen Plus™ in order to analyse the performance of different feedstock blends in bio-oil, biochar, and syngas production. The highest bio-oil yield (286 kg/hr) was obtained at a reaction temperature of 300°C, pressure of 5 bar, and a plastic-to-date seeds blending ratio of 100%, while the lowest bio-oil production (67 kg/hr) was achieved at a reaction temperature of 500°C, pressure of 5 bar, and a plastic-to-date seeds blending ratio of 0%. The highest biochar yield (592 hr/kg) was obtained at a reaction temperature of 500°C, pressure of 1 bar, and a plastic-to-date seeds blending ratio of 100%, while the lowest biochar production (246 kg/hr) was achieved at a reaction temperature of 500°C, pressure of 1 bar, and a plastic-to-date seeds blending ratio of 100%. The highest syngas yield (486 kg/hr) was obtained at a reaction temperature of 500°C, pressure of 1 bar, and a plastic-to-date seeds blending ratio of 100%, while the lowest syngas production (284 kg/hr) was achieved at a reaction temperature of 300°C, pressure of 3 bar, and a plastic-to-date seeds blending ratio of 50%. Overall, biochar and syngas yields were higher than bio-oil yields. A statistically significant correlation was found between the bio-oil yields and the plastic-to-date seeds blending ratio and between biochar yields and the plastic-to-date seeds blending ratio. These results show the suitability of co-pyrolysis of date seeds and tire plastic waste for bio-oil, biochar, and syngas production, that can be used simultaneously as a waste management strategy, but also as an alternative biofuel for the transportation, heating, cooling, and electricity sectors.

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Waste Biomass Hydrochars as Esterification Catalyst for Biodiesel Production

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Abstract:

While the adoption of electric motors in the road transport sector is progressing steadily, diesel engines are expected to remain in use for several decades. This makes it imperative to identify alternative fuels with lower pollutant emissions. Biodiesel (fatty acids methyl esters, FAME), derived from low-value vegetable oils such as waste frying oils (WFO), has emerged as a promising replacement for fossil diesel. However, these low-value oils are unsuitable for traditional transesterification using basic catalysis. Instead, a more effective approach involves WFO hydrolysis followed by acid esterification of the resulting free fatty acids (FFAs). Conventional esterification processes typically rely on strong inorganic acid catalysts, like H_2SO_4, but their use is associated with several well-documented drawbacks in the literature. Sulfonated biochar-based catalysts are highlighted in the literature as promising alternatives to strong inorganic acids for esterification reactions of FFAs. The catalytic efficiency of these biochars is highly dependent on the type of biomass used in their production, as well as the specific conditions under which they are prepared. Sulfonated hydrochars, prepared through hydrothermal carbonization (150°C, 1 atm, 5 hours) with simultaneous sulfonation (H_2SO_4/biomass weight ratio of 1:3), were tested in biodiesel x production via the methanolysis of oleic acid. These hydrochars were synthesized from food waste biomass, including banana and orange peels. For comparison, a hydrochar derived from sucrose was produced under identical conditions to serve as a reference for evaluating the catalytic performance. Catalytic tests conducted at the methanol reflux temperature, with a methanol-to-oleic acid molar ratio of 12:1 and a reaction time of 3 hours, revealed that the best catalysts achieved methyl oleate (FAME) yields exceeding 80%. The most effective catalyst was the sucrose derivative, which reached a maximum yield of 90%, remaining virtually unaffected by the sulphonation ratio used during preparation. This exceptional performance can be attributed to its high degree of graphitisation, as determined by Raman spectroscopy, which enhances hydrophobicity, and its favorable morphology, as observed through scanning electron microscopy (SEM). In contrast, X-ray diffraction (XRD) analysis of catalysts derived from fruit peels indicated the presence of crystalline calcium sulfate, which contributes to their lower catalytic activity since some of the sulfate groups bound to calcium are inactive in the esterification reaction. Water formed during the reaction, as well as moisture present in the oleic acid, acts as an inhibitor of the reaction. FTIR (Fourier-transform infrared)

spectroscopy of the catalysts after the reaction confirms the adsorption of water along with other species from the reaction medium. This water interferes with the complete conversion of oleic acid by shifting the chemical equilibrium unfavorably. Post-reaction analysis of the catalysts shows a loss of sulfonic groups; however, these catalysts can be reactivated through additional sulfonation. Water formed during the reaction, as well as moisture present in the oleic acid, acts as an inhibitor of the reaction. FTIR spectroscopy of the catalysts after the reaction confirms the adsorption of water along with other species from the reaction medium. This water interferes with the complete conversion of oleic acid by shifting the chemical equilibrium unfavorably. Post-reaction analysis of the catalysts shows a loss of sulfonic groups; however, these catalysts can be reactivated through additional sulfonation.

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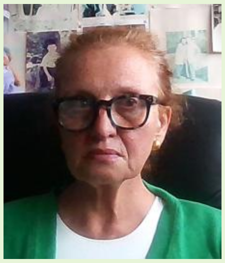

Evaluation of synergistic effect between biomass/hydrochar and plastic wastes during pyrolysis using Py-GC/MS technique

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Abstract:

In this STSM, the synergistic effect of sawdust (SD) and its hydrochar (H-SD) with high density polyethylene (HDPE) during pyrolysis were comparatively investigated. Hydrochar was obtained via hydrothermal carbonization of sawdust at 220°C with a residence time of 60 min. Thermal and catalytic pyrolysis of SD, H-SD, HDPE, and their blends with different ratios were performed at 500 °C using a micropyrolyzer coupled with GC/MS-FID. Pyrolysis of sawdust generated a high number of oxygenated compounds, including mainly phenolics, ketones, and aldehydes, with no aromatics found in the products. Similarly, pyrolysis products of H-SD were rich in oxygenated compounds, while it produced a considerable amount of furanic compounds and phenolics. A significant amount of levoglucosan was detected in H-SD, which was formed via hydrolysis of cellulose, following by dehydration of resulting glucose monomers. Furanic compounds in H-SD were found to be higher than those in untreated SD. Pyrolysis products of HDPE mostly included alkanes, alkenes, and alkadienes with various molecular weights, ranging between C3 and C20. Non-catalytic pyrolysis of blends (co-pyrolysis) showed no considerable synergistic effect for mono-aromatic hydrocarbon (MAH) production. The use of red mud as catalyst enhanced gas production during the pyrolysis of sawdust, hydrochar sawdust (H-SD), and HDPE. The relative area of MAH was found to be 6.4% for H-SD and 2.1% for H-SD in the presence of ARM whilst no MAH was detected in case of catalytic pyrolysis of SD alone. In contrast to the results of thermal co-pyrolysis of SD and HDPE, it was found that synergistic interactions occurred, significantly increasing aromatic production. Catalytic co-pyrolysis of SD and HDPE with a ratio of 2:1 produced up to 16.1% of MAHs (based on overall detected non-gaseous pyrolysis products).

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Short biography: Dr. Gozde Duman completed her PhD on production of hydrogen and bio-oil from biomass wastes at Organic Chemistry, Ege University (Turkey) in 2015. She is currently working as a lecturer at same department. She has been focusing on various thermochemical conversion of biomass and organic wastes; namely pyrolysis, steam gasification, hydrothermal processes and wastewater treatment. She has been involved in a number of national and international projects, studied at different research laboratories for short and long term visit, had collaborations with various research groups and published more than 30 peer-reviewed publications with high citations. Dr. Duman Taç is the co-founder of HOPE Biotechnology Startup (established in 2022), which specializes in the transformation of biomass and gas/solid wastes into value-added bioproducts by integration of biochemical processes with pyrolysis.

X-ray characterization of contaminated biomass derived char

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Abstract:

In the context of renewable energy and alternative fuels, “unconventional” lignocellulosic biomass is attracting great interest. An example of this biomass is represented by heavy metals contaminated biomass that come from polluted sites (i.e. marginal lands). Pyrolysis is a promising thermochemical valorization treatment for contaminated biomass; however, the presence of heavy metals raises environmental concerns tied both to their release during the process and to the utilization of the contaminated pyrolysis products. Therefore, it is fundamental to consider the displacement of heavy metals among pyrolysis products and their chemical speciation when processing heavy metals contaminated biomass.

In this framework, WIRE COST Action funded an STSM of one week at the UK Biochar Research Centre (UKBRC), School of GeoSciences, University of Edinburgh, Scotland (UK). The objective was to analyse a total of 25 samples of Pb doped biomass and pyrolysis derived char with X-Ray analytical techniques (XRD and XRF), aiming to investigate the chemical and mineralogical form of heavy metals contaminants. In particular, the biomass samples consist of poplar wood doped with Pb salts (lead nitrate, $Pb(NO_3)_2$, and lead acetate, $Pb(CH_3COO)_2$) following different doping procedures; the char samples are produced from pyrolysis of the considered biomasses at 465, 600 and 800 °C

XRD analysis highlighted the presence of Pb as lead oxide (PbO) in many of the samples and showed a morphological transformation of calcium carbonate ($CaCO_3$) from Calcite to Vaterite, which is caused by the high pyrolysis temperature

On the other hand, XRF analysis didn’t result in any additional information on heavy metal speciation: the XRF spectra confirmed the presence of Pb in the samples and also highlighted the presence of other trace elements. However, the content of trace elements on all the considered samples was already determined via ICP-MS, which is a more accurate technique. For this reason, only XRD analyses were carried out for all the biomass and biochar samples.

The obtained results are useful in the understanding of heavy metals speciation during pyrolysis of contaminated biomass, especially when coupled with other analytical techniques. For instance, the results obtained from XRD can be used for a more comprehensive interpretation of BCR sequential extraction, which divides the metal compounds into classes based on their mobility

without assessing a specific chemical form. In particular, PbO is only found in some specific samples, giving insights into the transformations that Pb undergoes during pyrolysis and highlighting that such transformations are dependent on the initial Pb speciation and bond with the biomass. Moreover, the presence of PbO results in more mobile Pb retained in the char.

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(BIO)MIMICRY AS AN ENGINEERING DESIGN TOOL FOR BIOREFINERIES

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Abstract:

Biomimicry, or biomimetics, involves the reflection or imitation of natural processes in human-designed systems. As the quest for sustainable resource management intensifies, biomimicry is emerging as a transformative engineering design tool for biorefineries. It offers innovative solutions inspired by nature to enhance efficiency and sustainability within circular economy models. Although biogas production—an application of the natural phenomenon of anaerobic biodegradation in engineered energy production systems—is not currently the most efficient approach, it can be significantly enhanced by using biomimicry for the valorization of lignocellulosic biomass in agricultural waste management. Moreover, biomimicry can also be instrumental in the physical design of biorefinery systems.
There are over sixty-five thousand research articles focused on biogas in the literature; however, most fail to address the microscale control of the biogas production process. Biorefinery systems are large and require significant instrumentation, whereas nature employs more efficient mechanisms for controlling energy and material production.
This paper examines research on applying biomimicry principles to enhance biorefinery processes. It also evaluates various biomimetic methodologies for application in biorefineries. The paper highlights the differences between natural and engineered systems, emphasizing the need for a scientifically supported approach to improve human-designed processes. Potential control parameters, such as temperature, pH, specific catalysts, and their process sequences, are evaluated. The results indicate that these common parameters can be effective in refining processes.
Using biomimicry in biorefinery design represents a forward-thinking approach that aligns industrial processes with natural principles, enhancing sustainability and efficiency. By adopting biomimetic strategies, biorefineries can minimize their ecological footprint, optimize resource use, and contribute to a more sustainable future.

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Biography**:** Selim Sanin is a professor in the department of environmental engineering at Hacettepe University and his research focuses on the biochemical processes of waste-line. He mainly investigates the mechanisms to degrade xenobiotic chemicals. His current research focus in on the beneficial use sludge from domestic and industrial sources. Modeling these systems are also inevitable focus of the research group.

Social life cycle assessment as a tool towards a sustainable society

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Abstract:

In the context of sustainability, the valorisation of residual biomass plays a crucial role in addressing the European Union's targets and commitments, particularly in alignment with the circular economy strategy. However, achieving holistic sustainability requires evaluating not only the environmental and economic impacts but also the social dimensions of the biomass valorisation process. While Life Cycle Assessment (LCA) has traditionally focused on environmental impacts, the inclusion of Social Life Cycle Assessment (S-LCA) offers a more comprehensive approach by addressing the social dimensions of biomass utilisation. This tool evaluates the social impacts along the entire value chain, from biomass acquisition to the final bioproduct, ensuring that these processes not only support environmental goals but also contribute to social well-being. This work explores how S-LCA could be a vital tool in promoting a sustainable society, especially in the context of communication and dissemination strategies.

The main objective is to understand how S-LCA can improve decision-making in biomass valorisation by integrating social, environmental, and economic dimensions. This study examines the role of effective communication and dissemination in raising public awareness of waste management, residual biomass, and its potential benefits. A well-informed society is key to driving sustainable practices. It is fundamental that sectors such as agriculture and forestry, as well as small producers, adopt new technologies and business models that support sustainability goals. A holistic review of both S-LCA and environmental LCA approaches is discussed, focusing on their application in the biomass sector. The key topic of this work includes the challenges in applying S-LCA to bioproducts and the role of communication and dissemination in promoting sustainable practices. It highlights the importance of integrating S-LCA into the decision-making process for biomass technologies and emphasises the need for enhanced communication and dissemination efforts to ensure that these technologies contribute to a sustainable society.

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Instagram as a science communication tool

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Abstract:

Instagram's visual and interactive features make it appealing to a wide range of users, from casual individuals to professional organizations. So, Instagram's visual and interactive nature makes it an effective tool for making science more approachable and enhancing public understanding of scientific topics. Many scientists, researchers, and organizations use it to effectively share their work and engage with the public, making it a science communication tool. As is the case of WIRE. A lot of researchers face difficulties in navigating science communication effectively, and Instagram can prove to be a simple solution to better disseminate our knowledge. In this poster, we will provide examples and explain why Instagram is the ideal tool for engaging young people who spend much of their time on social media, helping them to develop an interest in and appreciation for science. For WIRE, it has been a critical tool in the dissemination of meetings, STMS calls, announcements of special issues, and events related to WIRE, among others.

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A Patent Landscape Study: Advancements in Biorefinery Technologies for Sustainable Biomass Conversion

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Abstract:

Since the global move towards sustainable and renewable energy has driven significant research and innovation in biorefinery technologies, the interdisciplinary studies play a crucial role for shaping the future of biomass conversion. In order to comprehend the recent developments in sustainable biomass conversion, it is also needed to be analyzed of biorefinery technologies from the Intellectual Property IP-perspective. This study presents a condensed overview of an in-depth patent landscape study on biorefinery technologies for sustainable biomass conversion. The overview focuses on a dataset comprising carefully selected patent records over the last 2 decades, offering insights into key trends, emerging concepts, and inventive approaches within the field. The dataset encompasses a diverse range of patents and patent applications from various jurisdictions, shedding light on the global significance of biorefinery research. Through meticulous analysis, the study unveils a spectrum of innovative ideas that shape the biorefinery landscape. These patents encompass a wide array of concepts, ranging from novel methods for producing valuable products from biomass to advanced processes utilizing cutting-edge techniques. The dataset's content spans a rich tapestry of biorefinery technologies. Noteworthy innovations include efficient conversions of macroalgae, C1 substrates, and wastewater into biofuels and chemicals, reflecting the industry's drive toward sustainability and waste reduction. The interdisciplinary nature of biorefinery research is one of focal points this study. The patents reveal the integration of diverse fields such as hydrodeoxygenation, catalytic conversion, and energy-efficient drying, all aimed at optimizing biomass transformation. Notably, a considerable number of patents address environmental concerns, presenting inventive strategies for carbon emission reduction and toxin remediation. Resource efficiency emerges as a common thread, with patents showcasing ingenious approaches that utilize biomass processing residues and wastewater to obtain valuable resources like hydrogen for oil hydrogenation. These approaches not only align with sustainability goals but also exemplify the principles of the circular economy. In addition to highlighting technological advancements, the study explores the collaborative aspect of biorefinery research. With multiple applicants and assignees, including academic institutions and energy companies, the patents underscore the shared commitment to driving forward biorefinery technologies. In conclusion, this study provides valuable insights into the multidimensional nature of biomass conversion, innovation trends, and the interdisciplinary synergy that defines the evolution of biorefinery technologies thanks the IP landscape of biorefinery innovations of carefully monitored and selected patent records.

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Communication challenges among quadruple-helix stakeholders

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Abstract:

The importance of effective communication between different sectors of society has classically been underestimated. However, it is urgent and crucial to promote interdisciplinary collaboration between the quadruple-helix stakeholders, i.e., academia, civil society, government, and industry. Scientific findings tend to be found and understood mainly by those who work in that area of expertise, resulting in a sort of tunnel vision that limits information dissemination to the public. Civil society is normally alienated towards scientific developments either due to a lack of interest or to a perceived notion that science is difficult to understand due to jargon-filled speech and theoretically based ideas that have no apparent or concrete impact on their lives. Policymakers tend to pay more attention to ideas with a solid execution plan and to the expected impacts that the adopted measures will produce. Industries tend to treat their technological advancements with secrecy and have a more economically oriented view. Clearly, the four stakeholders composing the quadruple helix are quite different, all having their specific particularities. Nowadays, great emphasis has been placed on increasing communication efficiency between them, as they hold the power to produce highly positive impacts when an effective working synergy is attained. The production of public policies based on scientific findings, which can be far more effective, is one example of the impact provided by the synergistic action of these sectors. However, effective knowledge transfer between these stakeholders is not a simple task, as certain communication aspects should be adapted to maximize the audience reached and ensure that information is easily assimilated by the target groups. Information must be tailored to the intended audience, and given the wide variety of them, there is no "one-fits-all" method, and each case must be handled with care. The challenges and possible solutions to ensure effective communication between the quadruple-helix stakeholders, as well as the benefits of the cooperation between these sectors, will be discussed.

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Short biography: Henrique Federico Fichera Araújo finished his MSc degree in Chemical Engineering at Instituto Superior Técnico in 2023. Currently, he is a joint PhD student at the same institution and at a Portuguese company working on developing electrocatalysts and membranes for water electrolysis for green hydrogen production. Has been involved in science dissemination events to the general public, such as the European Researchers Night (2023, 2024), Técnico Open Day (2023, 2024), and the Portuguese Chemistry Olympics (2024).

Advancing Hydrogen Education through Collaborative Initiatives at IPPortalegre

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Abstract:

The Portalegre Polytechnic University (IPPortalegre) is actively contributing to the advancement of hydrogen technologies education through three key projects: H2Excellence, Futuretech_H2, and the Academy for Hydrogen (A4H2). These initiatives collectively demonstrate IPPortalegre's commitment to addressing skills gaps, promoting sustainable practices, and establishing itself as a leader in hydrogen education across various sectors. The project H2Excellence focuses on establishing Centers of Vocational Excellence (CoVEs) for fuel cells and green hydrogen technologies. IPPortalegre's involvement includes developing transnational curricula, facilitating exchanges between VET teachers and students, and integrating regional ecosystems into economic and innovation landscapes. In Futuretech_H2, IPPortalegre contributes to enhancing regional competitiveness in the hydrogen supply chain, aiming to establish synergies among transborder regions' hydrogen supply chain industries. And lastly, IPPortalegre's Academy for Hydrogen (A4H2) initiative solidifies the institute's commitment to fostering hydrogen competence and sustainable practices. Leveraging its VALORIZA research center, IPPortalegre has actively participated in practical projects, envisioning A4H2 as an academy of excellence offering specialized training in all aspects of the hydrogen value chain. Through H2Excellence, the institute ensures a well-rounded workforce with both technical expertise and a broader understanding of socio-economic and environmental implications. Futuretech_H2 emphasizes regional competitiveness, showcasing IPPortalegre's commitment to practical applications and real-world impact. A4H2 stands as the culmination of IPPortalegre's efforts, combining research initiatives, dedicated courses, and experimental laboratories to create a knowledge hub for hydrogen education. Overall, IPPortalegre's multifaceted approach to hydrogen education positions the institute as a driving force in shaping a skilled workforce capable of navigating the complexities of the evolving hydrogen landscape. Through these initiatives, IPPortalegre emerges as a leading institution in advancing hydrogen education, contributing significantly to sustainable and innovative practices across diverse sectors.

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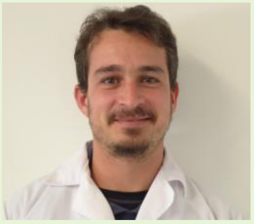

Short biography: Andrei Figueiredo Prates Longo has a degree in Biological Sciences in 2004, an MSc in Oceanography in 2009, an MBA in Environmental planning in 2010, and a PhD in Bioenergy in 2023. He is a researcher at the VALORIZA Research Center (Portalegre Polytechnic University), studying the thermochemical valorization of biomass wastes. He taught practical classes in Production of Liquid Biofuels and Food Quality II and co-supervised 1 MSc thesis. He has contributed to about 20 publications in his scientific career, including scientific articles, book chapters, and conference papers (https://orcid.org/0000-0002-5734-7270).

Special issues: important vectors of scientific production and dissemination

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Abstract:

Special issues are important editorial projects that differ in many ways from the articles regularly published by scientific journals. One particularly relevant aspect is the fact they are focused on a specific topic, attracting dedicated articles and specialized editors and reviewers. This can make the collection of articles published in such editorial issues an important vector for enhanced scientific quality and publicity for all the parties involved, including the host journals. Here, we will present a special issue, "Microbes vs. metals: Harvest and recycle", hosted by FEMS Microbiology Ecology. This project was edited by Lucian Staicu (University of Warsaw, Poland) and John Stolz (Duquesne University, Pittsburgh, USA), in collaboration with the editor-in-chief, Max Häggblom (Rutgers, The State University of New Jersey, USA). In this collection we have assembled a group of papers with a range of topics covering various chemical elements such as antimony, arsenic, copper, gold, iron, lead, manganese, selenium, tellurium, thallium and alloys (steel). They included contributions on metal resistance, biomineralization, microbial ecology, as well as several review articles. Overall, the above-mentioned contributions demonstrate the complex relationship microbes have with chemically-diverse elements from the periodic table, from transition and precious metals to metalloids and alloys. Either as pure cultures or as mixed microbial communities, microbes are able to colonize and modify diverse environments, thus impacting the mobility and biogeochemical cycles of the elements in nature. From a technological perspective, microbes act as cleaning agents in industrially-polluted environments, being exploited in approaches that are less aggressive than the conventional treatment systems. The presentation will cover the stages of preparing and running a special issue, providing first-hand insight into this type of editorial projects as an important tool of dissemination to the scientific community and the general public.

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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/

Effective Communication Strategies for Enhancing WIRE COST Action's Visibility and Stakeholder Engagement

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Abstract:

WIRE's communication plan is designed to effectively disseminate the Action's goals and results. It includes two levels: internal communication among the WIRE COST Action's members and external communication with stakeholders and the public. The key objectives are facilitating effective communication, achieving targeted outcomes, and continuously evaluating and improving communication efforts.
The plan emphasizes transparency, timely dissemination, and engaging content to maintain interest among diverse audiences while being mindful of resource constraints. Internally, WIRE uses tools like Google Drive, Colibri Zoom, and Microsoft Teams to enable secure and efficient collaboration.
Externally, a range of methods, such as the project website, social media (Instagram, LinkedIn, Facebook, Twitter), newsletters, webinars, conference special sessions, and journal special issues, are employed to maximize outreach and engagement with stakeholders. This approach ensures broad visibility and understanding of the WIRE's objectives and results.
WIRE's communication strategy benefits scientists by fostering collaboration, enhancing knowledge sharing, and increasing the Action's impact within the scientific community and beyond. The strategy is designed to be flexible and responsive, ensuring it meets the evolving needs of WIRE COST Action, its members, and stakeholders.

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Advancing Environmental Sustainability Through Waste Biorefinery Technologies: Insights and Innovations from the WIRE Cost Action Training School

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Abstract:

The growing global population, overexploitation of resources, and throwaway consumption patterns are intensifying pressure on waste management, making sustainable waste valorization for bioproduct and bioenergy production essential. In response to these challenges, this presentation highlights the integration of key concepts learned during the WIRE Cost Action Training School, titled 'Waste Biorefinery Technologies for Accelerating Sustainable Energy Processes,' into ongoing research focused on advancing environmental sustainability. The training covered critical areas such as sourcing sustainable feedstocks, valorizing agro-industrial residues, and integrating biorefinery processes into existing industries. Additionally, it explored market analysis, commercialization strategies, and scientific communication, equipping participants with the tools needed to translate research into practical applications. The collaborative nature of the workshop fostered an exchange of ideas and best practices among researchers, enabling me to explore new approaches for enhancing environmental sustainability in wastewater treatment. Specifically, I have integrated biochar and biogas production techniques into my research on treating toxic industrial wastewater from coke and maleic anhydride production. By combining the Fenton process with adsorption on bentonite clay, I aim to optimize wastewater treatment while converting hazardous byproducts into valuable resources such as biochar and biogas, in alignment with circular economy principles. Furthermore, this presentation highlights how these advancements contribute to the sustainability of wastewater treatment processes, emphasizing the potential for converting industrial waste into valuable resources. The insights gained during the Training School have not only amplified the environmental impact of my research but also opened new avenues for collaboration and innovation in waste valorization. Ultimately, this experience has had a significant impact on all participants, reinforcing our collective commitment to advancing environmental sustainability through innovative biorefinery technologies.

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