Waste biorefinery technologies for accelerating sustainable energy processes

Book of abstracts

WIRE's MC Meeting & 5th Working Groups Workshop

Istanbul Technical University (ITU)

Istanbul – Türkiye

18-19th April 2024

COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the European Union

Waste biorefinery technologies for accelerating sustainable energy processes

Book of abstracts - WIRE's MC Meeting & 5th Working Groups Workshop

EDITION

Instituto Politécnico de Portalegre

EDITORS

Diogo Santos, Roberta Panizio, Ana Carolina Assis, Catarina Nobre, Paulo Brito

ISBN

978-989-8806-78-9

Acknowledgements

This book of abstracts is based upon work from COST Action WIRE CA20127, supported by COST (European Cooperation in Science and Technology).

Welcome message

Welcome to the book of abstracts for the WIRE COST Action 5th Working Groups Workshop, held in Istanbul on April 18-19, 2024. This workshop brought together around **80** participants, showcasing roughly **40** abstracts accompanied by poster presentations. The event highlighted the importance of diversity, with a gender balance of **54% male and 46% female** attendees. Additionally, **young researchers constituted 60%** of the participants, and an impressive **82% hailed from ITC countries.** WIRE COST Action is organized into four key working groups (WG), which bring together experts from academia, industry, and technology transfer organizations:

WG 1: Raw Materials

WG 2: Biorefinery Conversion Technologies

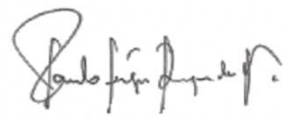
WG 3: Biorefinery Applications

WG 4: Communication and Dissemination

This workshop featured submissions with the following distribution across the working groups: **20.5% for WG1, 31.8% for WG2,** and **47.7% for WG3**.

As we are all aware, the global environmental challenges of rising temperatures and increasing waste demand innovative, sustainable solutions. Over the past 200 years, massive fossil fuel use has significantly increased carbon dioxide emissions, contributing to global warming. Concurrently, a growing population has led to higher production of wastes and effluents. Addressing these issues requires developing carbon-neutral sources and methods for energy and fuel production. The biorefinery approach to waste valorization is promising, offering almost neutral net carbon dioxide emissions compared to fossil-based feedstocks. By transforming biomass and organic waste into valuable materials, fuels, and energy, **biorefineries can significantly help achieve Europe's carbon neutrality goals by 2050**. This necessitates shifting from non-renewable to renewable resources to minimize environmental impacts. WIRE COST Action and its recent workshop in Istanbul played a vital role in promoting knowledge transfer and strengthening cooperation between academia and industry.

Together, we can develop sustainable solutions benefiting the environment, economy, and society. Thank you for your contributions and participation. Let's continue advancing the field towards a sustainable future.



Paulo Brito, Action Chair

Catarina Nobre, Science Communication Coordinator

Table of contents

From Waste to Energy: N-Doped Graphene from Waste Bottles as a Sustainable Electrocatalyst Support for Borohydride Fuel Cells

A. Balčiūnaitė[1], B. Šljukić[2], N.A. Elessawy[3], M.H. Gouda[3], D.M.F. Santos[2]
[1]Department of Catalysis, Center for Physical Sciences and Technology, 10257 Vilnius, Lithuania, email aldona.balciunaite@ftmc.lt
[2]Center of Physics and Engineering of Advanced Materials, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal, email diogosantos@tecnico.ulisboa.pt
[3]City of Scientific Research & Technological Applications (SRTA-City), 21934 Alexandria, Egypt

Abstract: The depletion of finite fossil fuel reserves and the resultant environmental pollution stemming from their overuse in energy generation pose significant challenges for the global community. Therefore, it is urgent to seek cleaner energy sources. Fuel cells have emerged as sustainable power sources, attracting increasing attention from researchers. They directly convert chemical energy from environmentally friendly compounds into electricity, offering intrinsic efficiency, non-pollution, silent operation, and reliability. Additionally, fuel cells enable using low cost non-noble metals as electrocatalysts, reducing reliance on noble metals. Alkaline fuel cells are particularly advantageous in this regard, as they facilitate using low-cost electrocatalysts. Moreover, challenges related to hydrogen transportation and storage can be addressed by employing liquid fuels in direct liquid fuel cell systems. Herein, direct sodium borohydride – hydrogen peroxide ($NaBH_4$-H_2O_2) fuel cells were assembled employing novel Ni@NG and PdNi@NG anode electrocatalysts. The Ni@NG and PdNi@NG materials were prepared using N-doped graphene as a sustainable electrocatalyst support. It was produced from the pyrolysis of waste polyethylene terephthalate (PET) plastic water bottles together with urea and Ni metal, followed by mixing with chloro palladium solution to achieve 5, 10, and 15 wt.% Pd loading (noted as PdNi_5@NG, PdNi_10@NG, PdNi_15@NG). The fuel cell tests were carried out at 25-55 ºC using an alkaline mixture of 1 M $NaBH_4$ + 4 M NaOH as the fuel and a 5 M H_2O_2 + 1.5 M HCl oxidant solution. The performance of the fuel cell was evaluated by recording the cell polarisation curves. The fuel cell displayed an open circuit voltage of 1.5-1.9 V for Ni@NG and PdNi@NG catalysts. A peak power density of 48 mW cm^{-2} was attained at 25 ºC, at a current density of 64 mA cm^{-2} and cell voltage of 0.75 V using the PdNi_15@NG anode electrocatalyst. The study demonstrates that Ni@NG and PdNi@NG are promising anode electrocatalysts for direct $NaBH_4$-H_2O_2 fuel cells.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Aldona Balčiūnaitė
Affiliation: Department of Catalysis, Center for Physical Sciences and Technology
Country: Vilnius, Lithuania

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

Potential assessment of biomass residues in Portugal

Ana Carolina Assis[1], Roberta Mota Panizio[1,2], Catarina Nobre[1], Paulo Mourão[3], Paulo Brito[1]

[1]VALORIZA - Research Center for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, Portugal, carolina.assis@ipportalegre.pt, rpanizio@ipportalegre.pt, catarina.nobre@ipportalegre.pt, pbrito@ipportalegre.pt.

[2]MEtRICs - Mechanical Engineering and Resource Sustainability Center, Chemistry Department, School of Science and Technology, NOVA University of Lisbon, Portugal

[3]MED – Mediterranean Institute for Agriculture, Environment and Development & CHANGE – Global Change and Sustainability Institute, Departamento de Química e Bioquímica, Escola de Ciências e Tecnologia, Universidade de Évora, Pólo da Mitra, Ap. 94, 7006-554 Évora, Portugal.; pamm@uevora.pt

Abstract: This study endeavored to evaluate the extent of biomass waste in Portugal, a small country. Considering Portugal's circumstances, there is substantial potential for residual biomass. The main tree species discovered in Portugal include pine, eucalyptus, holm oak, cork oak, and chestnuts. In the mainland region of Portugal, it is estimated that an annual supply of around 6.5 million tons of biomass waste is accessible, with 2.2 million tons being forest biomass waste. However, it is crucial to recognize that fluctuations in climate, topography, economics, society, demand, and quality may impact the quantity and origin of this waste. Biomass can be derived from a range of sources, including biomass waste, which comprises forestry and industrial waste of a forestry nature, agricultural and agri-food industry waste and its effluents, animal waste from animal farms, the organic fraction of municipal solid waste, effluents from urbanization, and energy crops, including short rotation crops. The form of processing necessary to transform biomass or waste into biofuels is contingent upon the origin and traits of the material. Biomass has the capacity to support not only the energy sector but also secondary industries such as cellulose, sawmills, pellets, and other value-added wood products, presenting new opportunities for economic growth. Other sources possessing significant potential exist as well. As an example, winery waste may be valorized. Olive oil production waste, primarily composed of olive pomace and seeds, is another vital biomass waste in Portugal. Biomass residues possess the ideal properties for adsorption processes once they have been carbonized, and it is the chars derived from lignocellulosic sources that exhibit the most effective adsorption mechanisms. So is paramount to understand the quantity of biomass waste present in a specific nation to assess its recovery prospects.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). The authors acknowledge the financial support provided by Fundação para a Ciência e Tecnologia - Ministério da Ciência, Tecnologia e Ensino Superior (grant no. UI/BD/154425/2022) and it was supported by national funds through the Fundação para a Ciência e Tecno- logia, I.P. from UIDB/05064/2020 (VALORIZA- Research Centre for Endogenous Resource Valorization) and by a grant UI/BD/154425/2022.

Details of presenting author

Name: Ana Carolina Assis
Affiliation: *VALORIZA - Research Center for Endogenous Resource Valorization, Polytechnic Institute of Portalegre*
Country: Portugal

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

Sustainable Energy Generation from Organic Waste in Circular Economy Models

Ana Momčilović[1] and Marta Trninić[2]
[1]*Belgrade Polytechnic, The Academy of Technical Applied Studies, Belgrade, Serbia, amomcilovic@atssb.edu.rs*
[2]*Belgrade Polytechnic, The Academy of Technical Applied Studies, Belgrade, Serbia, mtrninic@atssb.edu.rs*

Abstract: In the current landscape of environmental sustainability, the management of organic waste emerges as a pivotal challenge, demanding innovative solutions. This study delves into the realm of energy recovery from organic waste, situating the research within the broader framework of a circular economy and adhering to the principles of the bioeconomy. Through a methodical approach combining theoretical understanding and empirical investigations, this research aims to unlock the full potential of organic waste as a sustainable energy source. The research methodology employed a series of meticulously designed experiments, which were underpinned by robust mathematical modelling. These experiments focused on examining various organic waste compositions under controlled conditions. The primary objective was to decipher the optimal mixtures and processing conditions that would facilitate maximum energy extraction. This experimental design was crucial in understanding the intricate dynamics of organic waste conversion into energy. At the heart of this study lies the ambition to efficiently harness organic waste, typically regarded as an environmental burden, and transform it into a renewable and sustainable energy resource. This aligns seamlessly with the ethos of sustainable bioeconomic strategies, which advocate for the judicious use of biological resources to drive economic growth while ensuring environmental conservation. The findings of this study are a testament to the untapped potential residing in organic waste as a viable energy source. A notable outcome of the research is the identification of key factors that significantly enhance the energy recovery process. By fine-tuning these factors, a marked improvement in the efficiency of energy extraction from organic waste was observed. These factors include the composition of the waste, the conditions under which it is processed, and the methods used for energy conversion. The study not only demonstrates the feasibility of this approach but also underscores its necessity in the broader context of environmental sustainability. The research presents a compelling argument for a paradigm shift in how organic waste is perceived and managed. By integrating bioeconomic principles, which emphasize the sustainable use of biological resources, the study illustrates how organic waste management can evolve from a linear 'dispose-and-forget' model to a circular, value creating process. This transformation is pivotal in mitigating environmental impacts, particularly those associated with waste disposal and energy production. Furthermore, the study underscores the critical role of interdisciplinary approaches in tackling complex environmental challenges. It blends insights from biology, chemistry, environmental science, and economics, illustrating the multi faceted nature of sustainable waste management and energy recovery. In conclusion, this research provides a comprehensive and nuanced understanding of energy recovery from organic waste within the context of a circular economy and bioeconomy. It highlights the significant potential of organic waste as a sustainable energy source and outlines practical ways to enhance the efficiency of this process. The implications of this study are far-reaching, offering valuable insights for policymakers, industry stakeholders, and researchers.

By demonstrating the viability and necessity of converting organic waste into sustainable energy, the study paves the way for a more sustainable and environmentally responsible future, aligning economic growth with ecological preservation.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Ana Momčilović
Affiliation: The Academy of Applied Technical Studies Belgrade
Country: Serbia

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

Artificial Intelligence Approach in Anaerobic Digestion for Sludge Treatment in Wastewater Treatment Plants

Alia Saleh[1] **and Atıf Emre Demet**[2]
[1]*Department of Energy Systems Engineering, Necmettin Erbakan University, Konya, Türkiye, aedemet@erbakan.edu.tr*
[2]*Department of Energy Systems Engineering, Necmettin Erbakan University, Konya, Türkiye*, *salehalia97@gmail.com*

Abstract: Managing sewage sludge is a major obstacle that wastewater treatment facilities face, requiring significant financial and administrative resources. Proper disposal of the sludge is crucial to prevent environmental harm, and the process can involve complex procedures such as dewatering, and stabilization. Anaerobic Digestion (AD) is a biological process in which microorganisms break down organic matter in the absence of oxygen. This technology is widely recognized as one of the most efficient and effective ways of treating sludge, which is a byproduct of wastewater treatment. By using AD technology, sludge can be converted into biogas and nutrient-rich fertilizer, which can then be used as renewable energy and soil conditioners. AD technology is still in use not only because of its high efficiency but also because it aligns with the principles of the circular economy by promoting the recycling and reuse of resources. This is because it helps in reducing the generation of sludge waste and converting it into a renewable source of energy and fertilizers at the same time. The use of artificial intelligence is a successful method for addressing the difficulties associated with traditional mathematical modeling in anaerobic digestion. The purpose of this article is to provide a concise introduction to the prevalent AI-driven models utilized in anaerobic digestion technology. These models include artificial neural networks, support vector machine, decision trees, fuzzy inference system, principal component analysis, genetic algorithms, and particle swarm algorithms. The article discusses the various ways in which AI can be used in anaerobic digestion, including the monitoring of process stability, optimization of biogas yield, enhancement of microbial community activity, and fault detection. Additionally, the article highlights the limitations of AI models and identifies trends that should be considered in the future.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Atıf Emre Demet
Affiliation: Necmettin Erbakan University (NEU)
Country: Türkiye

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

Garden waste anaerobic co-digestion with sugarcane bagasse to attain high biogas production

Beni Lew[1], **Shir Siman Tov**[2], **Rubia Gaur**[3] **and Abid Ali Khan**[4]
[1]*Department of Civil Engineering, Ariel University, Ariel, Israel, benilew@ariel.ac.il*
[2]*RePower, Ramat Gan, Israel, info@repower.co.il*
[3]*Tech-Bulls Research, New Delhi, India, techbullsresearch@gmail.com*
[4]*Jamia Millia Islamia, New Delhi, India, akhan23@jmi.ac.in*

Abstract: Lignocellulosic biomasses such as Garden Waste (GW) are regarded as major contributors to organic solid waste in urban-industrial areas; however, due to its high lignocellulose content, low biogas yield is observed. Anaerobic co digestion (AcoD) is a feasible approach for increasing biodegradability and biogas production. This study evaluates AcoD of pre-treated GW with sugarcane bagasse (SB). First, different grinding times (30, 60, and 90 s) were investigated to select optimum particle sizes of substrates. The grinding time of 60 s showed more homogenous size distribution and the highest reduction in the size; for this reason it was used for further experiments. The biogas potential study was carried out with GW:SB at different mass/mass ratios: 1:0 (T1); 0:1 (T2); 0.66:0.33 (T3); 0.5:0.5 (T4) and 0.33:0.66 (T5). As expected, co-digestion (T3, T4 and T5) showed improved biogas production in comparison to T1 and T2. T1 showed the lowest biogas production and T2 showed a high biogas production. T4 (0.5:0.5 GW:SB ratio) showed the highest biogas production, around 8.4 mL biogas* g VSS^{-1}* mg $sCOD^{-1}$, highest biodegradability, 0.74 and sludge activity, 0.41 g COD biogas* g VS^{-1}. Pre-treatment energy requirement is 4 scale of magnitude lower than the energy produced in the reactors and, the co-digestion improved biogas production by two fold, making co digestion of pre-treated GW and SB a feasible option.

Details of presenting author

Name: Beni Lew
Affiliation: Ariel University
Country: Ariel, Israel

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

Harnessing Agricultural Biomass: Production, Utilization, and Sustainable Practices

Bogdan-Marian Tofanica

"Ion Ionescu de la Brad" Iasi University of Life Sciences, Iasi, Romania, b.m.tofanica@gmail.com

Abstract: Agricultural biomass holds immense promise in the realm of pulping, offering renewable feedstock for various sustainable products: materials, chemicals, energy. This presentation delves into the intricate interplay between agricultural biomass and pulping processes, exploring the diverse array of agricultural residues, including wheat straws, maize, and rapeseed stalks in sustainable pulp production processes, as potential raw materials. We unravel the challenges and opportunities inherent in utilizing agricultural biomass for pulp production, considering factors such as feedstock availability, fiber quality, and process optimization. From traditional pulping methods to innovative biorefinery approaches, we examine the evolution of agricultural biomass utilization in the pulp and paper industry. Moreover, we spotlight sustainable practices and technological advancements aimed at enhancing resource efficiency, reducing environmental footprint, and fostering circularity in the pulp production cycle. By elucidating the synergies between agricultural biomass and pulping processes, the presentation aims to inspire sustainable strategies for the industry while underscoring the pivotal role of agricultural residues in shaping the future of pulp production.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Bogdan-Marian Tofanica
Affiliation: "Ion Ionescu de la Brad" Iasi University of Life Sciences
Country: Romania
Short biography: Bogdan-Marian Tofanicais an accomplished researcher with extensive expertise in sustainable pulp production and agricultural biomass utilization. With a background in chemical engineering, Bogdan specializes in optimizing pulping processes and exploring innovative solutions for the valorization of agri-wastes. His research interests lie at the intersection of environmental sustainability and industrial innovation, aiming to drive positive change in the pulp and paper sector. Bogdan's commitment to advancing sustainable practices and circular economy principles underscores his dedication to creating a greener future for the pulp industry.

Model of Integrated First and Second Generation Bioethanol Production From by-Products of Sugar Beet Processing

Bojana Bajić, **Damjan Vučurović, Siniša Dodić**
University of Novi Sad, Faculty of Technology Novi Sad, Department of Biotechnology
Bulevar cara Lazara 1, 21000 Novi Sad, Serbia, baj@uns.ac.rs

Abstract: Bioethanol represents a valuable raw material in the food and pharmaceutical industry, and a partial or complete replacement for fossil fuels. Bioethanol production, with the aim of its application as a biofuel, must achieve the cheapest possible production to reach market competitiveness with the price of fossil fuels. The final price of bioethanol is influenced by numerous factors, such as the raw material cost, the type of production microorganism, the applied fermentation procedure, the annual production capacity and the additional annual costs, the amount and type of energy used in the production process itself, the price of the obtained by-products, etc. Bioethanol is mainly produced by fermentation from sugar or starch-containing raw materials as first-generation bioethanol, while production from lignocellulosic materials still needs to be developed. The challenges of second-generation bioethanol production can be partially overcome by integrating first and second-generation production. This research will predict process and economic indicators of the analysed biotechnological process and evaluate the possibility of integrating the production of first and second-generation bioethanol from the by-products of sugar production, molasses, and sugar beet pulp, by generating a simulation model of the production process using the SuperPro Designer process simulator. The developed model of the integrated first- and second-generation bioethanol production represents an economically profitable bioprocess and an excellent basis for further improvement of the efficiency of this biotechnological process.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (451-03-65/2024-03/200134).

Bioethanol Production From Starch-Based Food Waste From Student Restaurants

Vesna Vučurović, Bojana Bajić, Uroš Miljić, Damjan Vučurović, Vladimir Puškaš, Siniša Dodić

Department for Biotechnology, Faculty of Technology Novi Sad, University of Novi Sad, Novi Sad, Republic of Serbia, email: vvvesna@uns.ac.rs

Abstract: Bioethanol is currently one of the most important alternative biofuels for the replacement of fossil fuels, with the constant growth of produced volume in the global market over the last few decades. Nowadays, about 99% of the global bioethanol is produced from feedstocks containing sugar (sugar cane, sugar beet, molasses, sweet sorghum, fruits, etc.) or starch-containing feedstock (corn, wheat, barley, and other cereals, potato, etc.). However, the use of these feedstocks for biofuel production causes food competency. The feedstock cost contributes about 40-75% of the final price of the ethanol product, depending on the type of used biomass. The use of low-priced feedstocks containing sugar or starch such as food waste from kitchens or restaurants represents an attractive option to reduce the cost of bioethanol production. Food waste application as feedstocks in biorefinery has received major attention due to its abundance and immense potential for conversion into value-added products including bioethanol. Besides, this approach also includes food waste management to overcome environmental problems. Namely, food residues are usually landfilled or incinerated, which may cause groundwater contamination or emission of noxious gases and dioxins. Hence, besides providing economic advantages the production of bioethanol from kitchen waste is offering advantages of protecting the environment as well as conserving resources and enabling savings in waste disposal costs. This work aimed to investigate the potential of different starch-containing food waste from student restaurants as feedstock for bioethanol production by separate hydrolysis and fermentation (SHF) using *Saccharomyces cerevisiae*. Leftover starch-containing food waste which is usually on the daily menu in student restaurants was collected and separated by the type of prepared meal (wheat bread leftovers, white rice, green pea stew, green beans stew, mashed potatoes, white beans stew). Waste was grounded and diluted with tap water to prepare media for fermentation. Thermo-enzymatic pretreatment of these raw materials for starch liquefaction and saccharification was conducted using a combination of two technical enzymes thermostable α-amylase and glucoamylase. Afterward, the samples were subjected to alcoholic fermentation with *Saccharomyces cerevisiae*. The obtained results implied that the thermo-enzymatically pretreated kitchen waste can be potentially used for ethanol production to obtain ethanol yield in the range from 12.3 L for green pea stew to 41.7 L for wheat bread leftovers per 100 kg of waste dry matter.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (451-03-65/2024-03/200134).

Details of presenting author

Name: Bojana Bajić
Affiliation: University of Novi Sad, Faculty of Technology Novi Sad, Department of Biotechnology
Country: Serbia

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

New approaches on thermochemical biomethane production

Bruna Rijo, **Catarina Nobre, Paulo Brito**

[1]VALORIZA—Research Centre for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, Portalegre, 7300-555, Portugal, bruna.rijo@ipportalegre.pt

Abstract: These days, the ongoing decarbonization of energy and transport systems is a topical challenge in Europe. With the rising prices of fossil natural gas highlighting the need to increase renewable gas capacity and develop biomethane production technologies, there is a need to design new concepts for the efficient and cost-effective production of biomethane, particularly through thermochemical technologies combined with renewable hydrogen production. There are many ways to pursue a new technological path, in this work, three significant steps are highlighted:

1) Feedstock: Innovative crop rotation systems with intermediate catch crops can represent a feedstock solution. These crops, grown in rotation with food and feed crops, will produce additional biomass without requiring additional lands. This approach enhances knowledge of innovative cropping systems and diversifies the feedstock supply.

2) Advanced gasification processes, like SEG/Oxy-SEG should be more explored. This process is ideal for the high production of syngas and flue gas with a wide application scope for biomethane production. The SEG/Oxy-SEG concept offers an interchangeable hybrid process that simplifies syngas conditioning downstream and enhances biomethane synthesis by enabling flue gas conversion and *in situ* CO_2 capture. This flexible solution can convert low-grade feedstocks, diversify the current feedstock benchmark in biomethane production, lower costs, and increase carbon efficiency.

3) New approaches on catalytic methanation process by using a fluidized bed. This process enables the delivery of high-quality biomethane. The key innovation is the flexible addition of an auxiliary flux of renewable hydrogen, which allows for the conversion of as much flue gas (CO_2) as possible, increasing overall carbon efficiency and potentially doubling the biomethane yield.

Together, these steps can form the foundation for a more sustainable and efficient biomethane production system, addressing the urgent need for renewable energy solutions in Europe.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). The authors would also like to thank the Fundação para a Ciência e a Tecnologia, I.P. (Portuguese Foundation for Science and Technology) under project UIDB/05064/2020 (VALORIZA – Research Centre for Endogenous Resource Valorization) and the HYFUELUP project (European Union's Horizon Europe research and innovation programme) under grant agreement no. 101084148.

Details of presenting author

Name: Bruna Rijo
Affiliation: VALORIZA—Research Centre for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, Portalegre, 7300-555, Portugal
Country: Portugal

Short biography: Bruna Rijo is an Invited Assistant Professor at Portalegre Polytechnic University and a Researcher at the Research Center for Endogenous Resource Valorization (VALORIZA), studying the valorization of waste to produce renewable gases. She received a MSc degree in Chemical Engineering from IST, University of Lisbon, in 2013 and a PhD in Refining, Petrochemical, and Chemical Engineering from IST, University of Lisbon, in 2018. As a result of her research activities, she has contributed 20 publications in peer-reviewed journals, mostly Q1 journals, and more than 15 presentations at conferences.

Solar-aided and conventional HTL study on agri-food industry residues

Charikleia A. Poravou[1], Nikolaos I. Tsongidis[2], Christodoulos Lekkos[3], George Karagiannakis[4]

[1]*Centre for Research & Technology Hellas (CERTH)/ Research Engineer, Thessaloniki, Greece, cporavou@certh.gr*
[2]*Centre for Research & Technology Hellas (CERTH)/ Collaborating Researcher, Thessaloniki, Greece, ntsongid@certh.gr*
[3]*Centre for Research & Technology Hellas (CERTH)/ Research Engineer, Thessaloniki, Greece, lekkos@certh.gr*
[4]*Centre for Research & Technology Hellas (CERTH)/ Principal Researcher Engineer, Thessaloniki, Greece, gkarag@certh.gr*

Abstract: The last decade, Hydrothermal Liquefaction (HTL), a thermochemical method for the production of biofuels through the processing of residual organic biomass, has attracted significant interest from researchers [1,2]. Sub- or supercritical water conditions (250-550ºC, 5-25 MPa) are used to induce the macromolecules decomposition and oil compounds formation by repolymerization of unstable fractions [3]. The advantages of HTL are the minimum needs of the feedstock pretreatment and the possibility of byproducts stream valorization in various applications. The final biocrude, a dark viscous oil can be further upgraded in order to attain fuel-like properties [4].

The current study focused on the agri-food residues hydrothermal liquefaction under temperatures ranging from 300 to 350ºC and two initial pressures (1, 20 bar). N_2 was used as purging gas in a 1.8L stirred autoclave reactor including an electric heater, and the experimental procedure was held with a retention time of 30 min. The tests were repeated in a non-stirred reactor operating under artificial light provided by a Solar Simulator, attempting to compare the conventional heating with a Concentrating Solar Technology (CST). Both procedures were evaluated by calculating the biocrude yield using the following equation:

$$\mathbf{Biocrude\ yield}(\%) = \frac{\mathbf{w}_{\mathbf{bio}\boldsymbol{crude}}}{\mathbf{w}_{\mathbf{feedstock}}}\,\mathbf{x\ 100}$$

Where $w_{biocrude}$ and $w_{feedstock}$ are the weight of the biocrude (g) and the dried feedstock, respectively. Additional values were tested for the process assessment such as the temperature and pressure rise rates. Furthermore, the liquid products were characterized in terms of elemental analysis and Higher Heating value, while the gaseous phase composition was determined by a gas chromatographer (GC). The biocrude yield showed increased values in the case of the solar simulator as the heating means of the process compared to the ones using the conventional electric heater, indicating promising HTL results with the addition of CST in the process.

References

[1]Elliott, D. C. et al., Algal Res. 2(4), (2013), 445–454.
[2]Akhtar, J., & Amin, N. A. S., Renew. Sustain. Energy Rev. 15 (3), (2011), 1615–1624.
[3]Chen, W. T. et al., Algal Res. 25, (2017), 297–306.
[4]Poravou, C. A., Waste Biomass Valori. 13(9), (2022), 3835–3844.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Charikleia Poravou
Affiliation: Research Engineer
Country: Greece

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

Biochar as Methane Booster in Anaerobic Digestion of Food Waste

Ciro Florio[1,2], Paola Giudicianni[3], Corinna Maria Grottola[3*], Domenico Pirozzi[2], Vincenzo Pasquale[1], Raffaele Ragucci[3], Stefano Dumontet[1]

[1]*University of Naples "Parthenope", Department of Science and Technology (DiST), Naples (Italy)*
[2]*University of Naples "Federico II", Department of Chemical Engineering, Materials and Industrial Production (DICMaPI), Naples (Italy)*
[3]*Institute of Sciences and Technologies for Sustainable Energy and Mobility (STEMS) of the National Research Council (CNR), Naples, Italy corinnamaria.grottola@stems.cnr.it*

Abstract: A great advantages of the anaerobic digestion of food waste is both the volume reduction and the production of biogas, mainly methane. The methane production is even more promoted in presence during the process of carbonaceous additives such as activated carbons. Herein, is proposed to consider and alternative bio based carbonaceous material as biochar for improving both the operational stability and the energetic output of anaerobic digestion. Specifically, the main issue is to assess and quantify the increase of CH_4 yields induced by the biochar addition and to identify all the main mechanisms responsible of this improvement. The risk related to the Polycyclic Aromatic Hydrocarbons (PAHs) release from biochar in the anaerobic digestion media was discussed as well. To this aim, biochar obtained from steam assisted slow pyrolysis of Populus nigra L. at 600 °C was used. Anaerobic digestion of food waste mixture was carried out in a batch reactor in mesophilic conditions (T= 37 °C). Four tests were conducted by adding 0, 1, 4 and 10 wt% of biochar on wet food waste mixture basis. Preliminary results showed that in the first hours CH_4 is produced of the anaerobic digestion test when 10 wt% of biochar was added to the food waste mixture (about 65 wt% more at 96 h), thus denoting a reduction of the lag phase. Increasing the biochar addition in the food waste mixture from 4 and 10 wt%, increased the CH_4 yield of 14 and 42%. In conclusion, results of the analyses of both the liquid phase during the tests and biochar recovered at the end of anaerobic digestion process revealed that biochar favoured the decomposition of acetic acid, adsorbed some inhibitors such as butyric acid, and provided a suitable habitat for microbial colonization.

Waste biorefinery technologies for accelerating sustainable energy processes

Details of presenting author

Name: Corinna Maria Grottola
Affiliation: Institute of Sciences and Technologies for Sustainable Energy and Mobility of the CNR, STEMS-CNR Country: Naples, Italy

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

Directing Türkiye's Bioenergy Potential: The Need for Tailored Modeling Towards Sustainable Energy Transition

Elif Ayhan and **Selim Latif Sanin**
[1]*Environmental Engineering Department, Hacettepe University, Ankara, Türkiye, eaelifayhan@outlook.com*
[2]*Environmental Engineering Department, Hacettepe University, Ankara, Türkiye, sanin@hacettepe.edu.tr*

Abstract: Climate change poses significant risks to Türkiye's energy supply and security, particularly given Türkiye's geopolitical position. To address this complex challenge, a tailored modeling approach has been developed for Türkiye, with the aim of achieving targets by 2053. Currently, Türkiye's energy supply relies on classical resources such as solid fuels, oil, natural gas, and renewables (Figure 1). Between 1990 and 2021, Türkiye experienced a remarkable 203% increase in total primary energy supply. Fossil fuels accounted for 84.5% of the total primary energy supply, while renewable energy sources contributed 15.6% in 2021. Renewable energy is derived from biomass resources (16%), hydraulic resources (19%), geothermal resources (45%), wind (11%), and solar energy (8%).

In 2020, Türkiye's energy sector was the highest greenhouse gas emitter, accounting for 70.2% of total GHG emissions. Our modeling efforts prioritize addressing climate change challenges in Türkiye's energy sector, with a specific focus on using bioenergy potential as the solution. Agricultural waste, wood waste, and municipal solid waste emerge as key components of Türkiye's bioenergy landscape. This modeling framework facilitates predictions regarding the transition to bioenergy and its scale. Preliminary findings suggest that improving both the number and quality of biorefineries in Türkiye will be instrumental in achieving this initial target. As a first step in utilizing system dynamics modeling, we aim to clarify uncertainties in available national energy supply data and identify gaps in the nation's renewable energy infrastructure (Figure 2), such as significantly low potential biomass, supply-demand data and models. Figure 2 is the result of various definitions of biomass, which may not be accurate. This holistic modeling integrates bioprocesses as feasible approaches for biorefineries, reshaping Türkiye's renewable energy roadmap, to address the challenges of climate change, efficient. By analyzing various parameters, including but not limited to, this evaluation aims to suggest strategic decisions and policy interventions that support Türkiye's transition to sustainable energy.

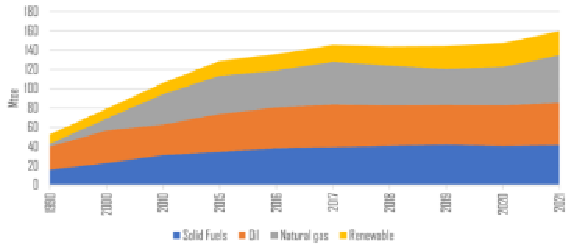


Figure 1- *Primary Energy Supply 1990-2021*

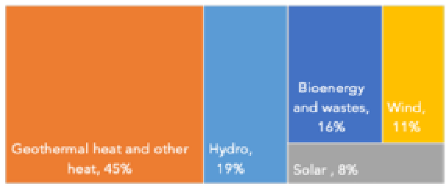


Figure 2- *The Share of Renewable energy by energy resources, 2021*

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Elif Ayhan
Affiliation: Hacettepe University
Country: Türkiye

Short biography: Elif Ayhan graduated from Hacettepe University, Department of Environmental Engineering in June 2023 and continues her master's degree in the same department. She continues her research on climate change, renewable energy, energy efficiency, and biorefinery. She has worked as a project assistant in 1 TUBITAK, and 1 UNDP project. She is the coordinator of the young climate envoys movement, which aims to raise awareness of climate change among university students, and to represent the climate envoys on different platforms. In November 2023, she attended COP28 with the Turkish delegation and gave a panel there.

From High Rate Algal Ponds to Biofilm Systems: Evolution and Prospects in Microalgae-Based Wastewater Treatment Technologies

Lia Freitas[1,2], Eoin Syron[1,2]
[1]UCD School of Chemical and Bioprocess Engineering Belfield, Dublin, Ireland.
[2] BiOrbic, Bioeconomy SFI Research Centre, O'Brien Centre for Science, UCD, Belfield, Dublin, Ireland
eoin.syron@ucd.ie

Abstract: The recovery and treatment of wastewater (WW) are crucial for preserving ecosystems and protecting public health. Over the last century, the increase in the world population has resulted in a decline in clean water sources, emphasising the need for more efficient wastewater treatment (WWT) engineering technologies. Studies have shown that up to 75% of the total WWTP energy costs can be attributed to the aeration needed to sustain biological activity during secondary treatment (Rosso et al., 2008). To tackle this, microalgae-bacterial based systems have been gaining increasing attention as bacteria can use the oxygen produced by microalgae to bioremediate wastewaters, all while microalgae fixate the resulting CO_2 from heterotrophic metabolism to perform photosynthesis. The capacity of bioaccumulation of nutrients rich in nitrogen and phosphorus, as well as the COD removal potential of microalgae, give to this group of microorganisms the advantage of enhancing bioremediation in mixed cultures, while also producing value added biomass that can be commercialised and/or used for energy production (El Semary, 2023). Nowadays, microalgae cultivation, in the context of wastewater, occurs mainly in high rate algal ponds (HRAP). These systems work in a suspended mode, where the cells float freely in the aqueous phase. Although the bioremediation efficiency in these systems are comparable to what has been seen in the conventional systems (Chokshi et al., 2016; Hongyang et al., 2011; Qin et al., 2014) this technique faces challenges such as susceptibility to contamination, reliance on environmental conditions, large land area demands and inversely proportional relation between scale and microalgal productivity (Nguyen et al., 2023; Sutherland & Ralph, 2020) which prevent their widespread adoption. To overcome these problems, the current approach for microalgae-based bioremediation and biomass cultivation is to increase process intensity by utilising algal/bacterial biofilms. Although the specifics reveal there are more intricacies to this protocol than what meets the eye, studies have shown that from an upstream and downstream perspective, algal biofilm systems can, in fact, outperform suspended ones (Gross et al., 2015; Mousavian et al., 2023). With this, in this present study, an examination of the state-of-the-art of HRAPs and other competing suspended configurations was conducted, in order to comprehend the limitations of this method and explore how biofilm-based systems could serve as a solution. Various studies investigating biomass productivity and nutrient removal were reviewed and summarised. Parameters influencing biofilm formation were studied to understand how the process could be intensified. Some highlights of this research include the dynamics of a multilayered algal-bacterial biofilm in nitrogen and phosphorus removal, the qualitative and quantitative improvements in the biochemical composition of biofilm cells, in comparison to suspended ones, as well as their potential applications in the energy sector and finally, the use of sustainable materials as a substrate for attached growth, namely solid waste. Addressing wastewater treatment challenges is vital for a sustainable future. As was shown, microalgae-bacterial systems show promise, but current HRAPs configurations face obstacles, therefore it is essential not only to generate innovative ideas but also to outline the necessary steps for their

implementation ensuring a seamless transition. This study consisted of a critical evaluation of suspended and attached growth systems. The findings contribute to a comprehensive understanding and assessment of the feasibility of implementing biofilm-based wastewater treatment technologies in the market.

References

Chokshi, K., Pancha, I., Ghosh, A., & Mishra, S. (2016). Microalgal biomass generation by phycoremediation of dairy industry wastewater: An integrated approach towards sustainable biofuel production. Bioresource Technology, 221, 455–460. https://doi.org/10.1016/j.biortech.2016.09.070

El Semary, N. (2023). Use of Algae in Wastewater Treatment. In M. P. Shah (Ed.), Recent Trends in Constructed Wetlands for Industrial Wastewater Treatment (pp. 161–176). Springer Nature. https://doi.org/10.1007/978-981-99-2564-3_8

Gross, M., Mascarenhas, V., & Wen, Z. (2015). Evaluating algal growth performance and water use efficiency of pilot-scale revolving algal biofilm (RAB) culture systems. Biotechnology and Bioengineering, 112(10), 2040–2050. https://doi.org/10.1002/bit.25618

Hongyang, S., Yalei, Z., Chunmin, Z., Xuefei, Z., & Jinpeng, L. (2011). Cultivation of Chlorella pyrenoidosa in soybean processing wastewater. Bioresource Technology, 102(21), 9884–9890. https://doi.org/10.1016/j.biortech.2011.08.016

Mousavian, Z., Safavi, M., Salehirad, A., Azizmohseni, F., Hadizadeh, M., & Mirdamadi, S. (2023). Improving biomass and carbohydrate production of microalgae in the rotating cultivation system on natural carriers. AMB Express, 13(1), 39. https://doi.org/10.1186/s13568-023-01548-5

Nguyen, L. N., Vu, M. T., Vu, H. P., Johir, Md. A. H., Labeeuw, L., Ralph, P. J., Mahlia, T. M. I., Pandey, A., Sirohi, R., & Nghiem, L. D. (2023). Microalgae-based carbon capture and utilization: A critical review on current system developments and biomass utilization. Critical Reviews in Environmental Science and Technology, 53(2), 216–238. https://doi.org/10.1080/10643389.2022.2047141

Qin, L., Shu, Q., Wang, Z., Shang, C., Zhu, S., Xu, J., Li, R., Zhu, L., & Yuan, Z. (2014). Cultivation of Chlorella vulgaris in Dairy Wastewater Pretreated by UV Irradiation and Sodium Hypochlorite. Applied Biochemistry and Biotechnology, 172(2), 1121–1130. https://doi.org/10.1007/s12010-013-0576-5

Rosso, D., Stenstrom, M. K., & Larson, L. E. (2008). Aeration of large-scale municipal wastewater treatment plants: State of the art. Water Science and Technology: A Journal of the International Association on Water Pollution Research, 57(7), 973–978. https://doi.org/10.2166/wst.2008.218

Sutherland, D. L., & Ralph, P. J. (2020). 15 years of research on wastewater treatment high rate algal ponds in New Zealand: Discoveries and future directions. New Zealand Journal of Botany, 58(4), 334–357. https://doi.org/10.1080/0028825X.2020.1756860

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Eoin Syron
Affiliation: UCD
Country: Ireland

Short biography: Eoin Syron, is an Assistant Professor in the School of Chemical and Bioprocess Eng UCD. His research focus is on the scale up and commercial application of Environmental and Energy processes. His research group are providing evidence to both the research and wider communities on how to make industrial scale systems more sustainable. Through system modelling, experimental data from laboratory and validated pilot scale systems they are investigating topics such as The sustainable treatment of industrial, municipal and agricultural wastes. The use of membrane based processes for industrial applications. The economic production of fuel from bio-resources. The production of energy from waste streams. The recovery of nutrients from waste streams. The role of Gas Network infrastructure in a future decarbonized energy system. The production, storage, transport and use of Green Hydrogen.

The role of phenylalanine in lignin production and wood formation

Francisco M. Cánovas, **Concepción Avila, Irene Blanca-Reyes, Beatriz Medina-Morales,María Teresa Llebrés, Vanessa Castro-Rodríguez**

Grupo de Biología Molecular y Biotecnología, Instituto Andaluz de Biotecnología, Facultad de Ciencias, Campus de Teatinos, Universidad de Málaga, SPAIN (canovas@uma.es)

Abstract: Biomass is a renewable source of energy, biofuels and a wide range of bioproducts with applications in chemical industries, cosmetics, therapeutics and in many other fields. Biomass production from forest trees, such as poplar and pine, holds immense potential as a valuable feedstock for biofuels and biorefineries. Progressive advances in the understanding of the molecular regulation of tree nitrogen economy open avenues to explore the production of biomass with the required characteristics for serving as feedstocks of specialized biorefineries. To harness this potential, gene manipulation of primary and secondary pathways involved in nitrogen metabolism of trees offers promising prospects for tailor-made biomass production. In this communication, an overview of recent advances made in the molecular regulation of phenylalanine biosynthesis and transport for lignin production and wood formation in forest trees will be presented and discussed.

References:

- Castro-Rodríguez et al. (2016). Plant Biotechnol J, 14: 299-312.
- Pascual et al (2018). Plant Biotechnol J, 16: 1094-1104.
- Cánovas et al. (2018). Front Plant Sci, 9:1449.
- El-Azaz J et al. (2020). J Exp Bot 71: 3080-3093.
- El-Azaz et al (2022) Plant Physiol, 188:134-150

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). Supported by EU FP7-KBBE-2011-5 (289841) and MICINN (RTI2018-094041-B-I00;PID2021-125040OB-I00; TED2021-129691B-I00)

Details of presenting author

Name: Francisco M. Cánovas
Affiliation: Universidad de Málaga
Country: Spain
Short biography: Francisco M. Cánovas is head of the Molecular Biology and Biotechnology Laboratory. He has been Director of the University Research Facilities, coordinator of the PhD programme in Molecular and Cell Biology and coordinator of Spanish Nitrogen metabolism. Principal investigator of more than forty national and international projects, author of 150 papers in SCI-indexed journals, 60 book chapters, 12 books and 7 patent applications.

Wood waste valorization by steam explosion

Audibert Edwige[1], Rémond Caroline[1], Gabriel Paës[1]

[1]FARE laboratory, INRAE, Université de Reims Champagne Ardenne, Reims, France, gabriel.paes@inrae.fr

Abstract: Wood wastes are among the most important biomass available resources in Europe. They are made of lignocellulose, which is a complex matrix of polysaccharides (cellulose and hemicelluloses) and lignin. They represent a promising alternative to fossil resources to produce biomolecules, biomaterials, and energy through biorefinery processes. However, the network formed by the lignocellulose constituents makes it recalcitrant to simple conversions, that is why some pretreatments are often applied to make biological process reactions easier and faster. Here we present the results of some projects where the steam explosion pretreatment was applied to different wood wastes by varying severity conditions, leading to the creation of large sets of samples. A wide multimodal approach was performed to assess their biochemical composition, spectral properties and physical architecture after pretreatment. This information was expertly gathered and related to the potential of the samples to produce fermentescible monosaccharides, in order to define the most optimal pretreatment conditions for different potential applications.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: PAËS Gabriel
Affiliation: FARE laboratory
Country: France

Short biography: Gabriel Paës is an INRAE research director heading the Fractionation of AgroResources and Environment laboratory. With a transdisciplinary educational background in biochemistry and physical chemistry of biopolymers, metabolic and enzyme engineering, with positions in academia and industry for more than 20 years, he has become an expert in lignocellulosic biomass characterization and valorisation in the bioeconomy context. In particular, he investigates biomass recalcitrance of various biomass species as raw and pretreated materials, by developing and applying multimodal approaches, in particular microscopy fluorescence-based techniques. His objective is to highlight universal features of biomass recalcitrance that could be easily measurable and turned into markers for sensors to be used in biorefinery processes.

Carbon dioxide catalytic reduction and synthesis of next generation fuels

Georgia Kastrinaki[1]*, Alexandra Bakratsa[1], Vasiliki Zacharopoulou[1], George Karagiannakis[1]

[1]ARTEMIS Laboratory, Chemical Process & Energy Resources Institute, CERTH, Greece

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

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Georgia Kastrinaki
Affiliation: *ARTEMIS Laboratory, Chemical Process & Energy Resources Institute, CERTH*
Country: Greece

Short biography: Georgia Kastrinaki is a Senior Research Scientist at the Centre for Research and Technology Hellas in Thessaloniki. She studied Physics at the Aristotle University of Thessaloniki (2004) and holds a MSc in Microsystems and Nanostructures from National Technical University of Athens and a PhD in Mechanical Engineering from University of W. Macedonia, Kozani. Her research activities focuses on the synthesis of nanostructured particles for energy, environmental and toxicological applications, with expertise in catalytic materials for particulate and gas treatment from Diesel engines, Li-ion batteries and toxicity assessment of nanoparticles and microplastics in living systems.

Switched Activation Functions-Based ML Algorithms: Boosting Bioeconomic Efficiency

Hacı Mehmet Güzey
[1]*Electrical-Electronics Engineering, Sivas University of Science and Technology, Sivas, Turkey,*
mehmet.guzey@sivas.edu.tr

Abstract: In the quest for a sustainable future, the development of efficient biorefinery processes is pivotal to the bio-based economy. Within this paradigm, the role of advanced machine learning algorithms, particularly those employing switched activation functions, becomes instrumental. This presentation explores the innovative integration of switched activation functions-based machine learning algorithms in enhancing the efficiency and adaptability of neural network-based adaptive control systems within the context of biorefinery processes.

Drawing upon extensive research in the application of neural networks for adaptive control in complex dynamic systems, this work extends the paradigm to the optimization of biorefinery conversion technologies. Switched activation functions provide a novel mechanism for improving the performance and robustness of machine learning algorithms, allowing for more precise approximation of uncertain system dynamics, a challenge often encountered in the processing of diverse biomass types into bioenergy and other valuable products.

This presentation will demonstrate how switched activation functions can optimize the control and processing in biorefinery applications, leading to more efficient resource use, reduced waste, and enhanced sustainability. The adaptability of these algorithms to varied and uncertain biomass input characteristics exemplifies their potential to contribute to the harmonization of biorefinery technologies across Europe, aligning with the WIRE COST Action's objectives to promote circular economy principles, bioenergy, and the bio-based economy at large.

Furthermore, this work underscores the importance of interdisciplinary collaboration between academia, industry, and technology transfer organizations in advancing the bio-based economy. By bridging the gap between advanced machine learning research and practical biorefinery applications, this presentation aims to foster dialogue and innovation within the WIRE COST Action working groups, contributing to the overarching goal of a harmonized, knowledge-driven approach to biorefinery implementation across Europe.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Hacı Mehet Güzey
Affiliation: Sivas University of Science and Technology
Country: Turkey

Short biography: Hacı Mehmet Güzey received his M.S. degree in mechanical engineering from Drexel University, Philadelphia, PA, USA, in 2011, and the Ph.D. degree in Electrical engineering from Missouri University of Science and Technology, Rolla, MO, USA, in 2016. He is currently working as an Assistant Professor with the Department of Electrical-Electronics Engineering, Erzurum Technical University, Erzurum, Turkey. He has authored and coauthored several journal articles and conference papers so far. His research interests include neural networks, adaptive control, sliding mode control, tracking, event-triggered control. He is in the management committee of a European Union Cost Action (CA16219) and a working group member of WIRE Cost Action (CA20127).

Kinetic metabolic model covering amino acid dynamics for sustainable production from renewable resources

Hilal Taymaz-Nikerel

Department of Genetics and Bioengineering, Istanbul Bilgi University, Istanbul, Turkey, hilal.nikerel@bilgi.edu.tr

Abstract: The production of chemicals by biological means is expected to make a significant contribution in achieving the goal of sustainable production of energy and materials worldwide. Therefore, microbial fermentation is used in industrial biotechnology to convert biological-based raw materials into useful chemicals. While the fermentation industry uses microorganisms, which are natural producers, it has focused on the use of microorganisms called cell factories with the development of technology in the field of genetics. In the metabolic pathway engineering of microorganisms, the approach frequently used to improve product formation is to make a well-educated prediction based on biochemical knowledge of the synthesis pathways that can direct the metabolic flux to a particular product. Then, this prediction needs to be put into practice by genetically modifying the microorganism, and the assumption needs to be confirmed experimentally. Genome-scale kinetic models can be used to calculate all major metabolic fluxes as a function of enzyme levels and enzyme kinetic properties for the development of microorganisms towards higher product yields. Thus, gene targets for metabolic pathway engineering will be identified and the need for genetic engineering and strain tests that require intense trial and error will be reduced. Kinetic models that predict the behaviour of metabolic reaction networks under different conditions are crucial to fully and quantitatively understand the relationship between any product pathway and its associated central metabolism. In this work, it is planned to develop a kinetic model, for an important industrial microorganism Escherichia coli, that can also express time-dependent intracellular amino acid concentration changes. Escherichia coli is selected for its use in the production of recombinant proteins, amino acids, and other chemicals, and for its long research history, ability to rapidly grow on inexpensive substrates, and well-characterized genetics. Strategies for the improvement of microbial production processes will be proposed with the analyses in this comprehensive model to be developed. Such a kinetic model will contribute not only to determining product optimization paths, but also to understanding intracellular regulations in a qualitative and quantitative manner.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Hilal Taymaz-Nikerel
Affiliation: Istanbul Bilgi University
Country: Turkey

Short biography: I studied chemical engineering during BSc and MSc at Bogazici University, Istanbul. During my PhD study at Department of Biotechnology, Delft University of Technology, in Netherlands, I worked on construction of in vivo kinetic model of central carbon metabolism in Escherichia coli through bioreactor experiments. My post-doctoral research at Vrije University Amsterdam included 'Computational modeling approaches and fluxomics'; then, through a personal grant at Bogazici University I worked on the intracellular effects of chemotherapeutic drugs using systems biology approaches in yeast. Since 2017 I am an assistant (then associate) professor at Department of Genetics and Bioengineering at Istanbul Bilgi University.

Assessment of Türkiye's Biomass Potential: A Comprehensive Review

İlker Özata[1] and Selim L. Sanin[2]

[1]*Department of Environmental Engineering, Hacettepe University, Ankara, Türkiye ilkerozata@gmail.com*

[2]*Department of Environmental Engineering, Hacettepe University, Ankara, Türkiye, sanin@hacettepe.edu.tr*

Abstract: Determining and presenting an effective use for biomass accepted by all stakeholders is not easy due to the multifaceted nature of biomass potential. When it comes to biomass, agriculture, environment, energy, and biomass based industry processes are intertwined. Another dimension is the increasing importance of the biorefinery approach in industrial processes and its potential effects on existing business processes. Although the use of geographic information systems and advanced analysis methods and tools has become popular over the years in analysing this potential, the level of detail and dynamic structure of the data needed for analysis pose challenges for policy developers. Again, the effective use of high-detail data in decision-making processes is not easy when externalities are high. The most comprehensive compilation on Türkiye's Biomass Potential is the Biomass Energy Potential Atlas (BEPA, https://bepa.enerji.gov.tr), which was put into service by the Ministry of Energy and Natural Resources and was last revised in 2019. BEPA is based on agricultural production statistics compiled by the Turkish Statistical Institute (TURKSTAT) and aims to determine the possible energy potential with defined parameters. According to BEPA, the estimated economic biomass energy potential is around 4 Million TOE, based on the scope of biomass in Turkish legislation. It should not be forgotten here that the scope of biomass in Turkish legislation is based on the focus on electricity production. Although there is a consensus on the effective use of biomass potential in Türkiye, difficulties are encountered in coordinating approaches on practical applications. In the study, based on BEPA data, the main driving forces behind the biomass potential, the areas where biomass potential is concentrated, the possible interactions of different potential areas with each other were discussed and visualized, and a basic evaluation of the potential approach in BEPA was made. With this evaluation, it is aimed to understand the vulnerability of the biomass resource to multidimensional effects and to increase the harmony between the political and practical processes carried out on biomass. It is thought that the study will support biomass studies to be carried out in Türkiye in these aspects.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: İlker ÖZATA
Affiliation: Hacettepe University
Country: Türkiye

Short biography: İlker ÖZATA is a chemical engineer who completed his master's degree on biodiesel life cycle analysis and is conducting his doctoral study on the evaluation of biomass potential at Hacettepe University. He worked as a technical expert at the Development Bank of Türkiye for more than ten years, mostly on the technical and environmental evaluation of energy projects. He has been working as an expert at the Ministry of Energy and Natural Resources since 2019 and is the coordinator of the biomass and geothermal energy group.

Biohydrogen and Biomass Production from Spent Coffee Grounds and Coffee Silverskin: A Sustainable Biorefinery Approach

Liana Vanyan[1] and Karen Trchounian[2]
[1]Department of Biochemistry, Microbiology and Biotechnology, Faculty of Biology, Yerevan State University, Yerevan, Armenia liana.vanyan@ysu.am
[2]Research Institute of Biology, Yerevan State University, Yerevan, Armenia k.trchounian@ysu.aml

Abstract: In the pursuit of sustainable energy solutions, the biorefinery approach emerges as a promising pathway to transform waste into valuable resources. This study investigates the potential of spent coffee grounds (SCG) and coffee silverskin (CS)—two prevalent by-products of the coffee industry—for biohydrogen and biomass production.
Our methodology involved treating CS and SCG via acidic hydrolysis separately before combining them in specific ratios. The substrates derived from *Coffee arabica* were processed in six mixtures, following acidic hydrolysis at concentrations of 6.5% w/v for CS and 4% w/v for SCG. The mixtures were as follows:

1. 25% CS / 75% SCG
2. 50% CS / 50% SCG
3. 75% CS / 25% SCG
4. 25% CS / 25% SCG / 50% distilled water
5. 50% CS / 25% SCG / 25% distilled water
6. 50% SCG / 25% CS / 25% distilled water

Escherichia coli BW25113 wild-type grown in peptone medium were suspended into waste medium. The growth process was monitored by measuring changes in Oxidation-Reduction Potential (ORP), pH, and Optical Density (OD) at a 600-nm wavelength.

Preliminary findings indicated that the first three ratios did not yield optimal results, likely due to the high concentration of carbohydrates and hydrolysis by-products, such as furfurals and phenolic compounds. For the remaining mixtures, H_2 production commenced at the third hour of growth and persisted until the 24-hour mark, achieving consistent yields of approximately 3.6 mmol L^{-1}. Under these identical conditions, the average biomass production reached 0.12±0.003 grams of cell dry weight (gCDW) per liter over a 72-hour cultivation period. The addition of 10 ml L^{-1} glycerol extended the duration of H_2 production. Notably, in the mixture comprising 25% CS / 25% SCG / 50% distilled water, H_2 production initiated at the 6^{th} hour and continued through to the 72^{nd} hour, with the yield of 5.15 mmol L^{-1} recorded at the 24-hour interval. Similarly, for mixtures with 50% CS and 25% SCG, and vice versa, supplemented with 25% distilled water, hydrogen production began at the 24^{th} hour and extended until the 96^{th} hour, with the highest yield observed being 3.5 mmol L^{-1}. Concurrently, biomass production reached the highest level of 0.147±0.003g CDW by the 120th hour of growth.

These results underscore the efficacy of diluted mixtures for biohydrogen and biomass production, suggesting a cost-effective strategy for leveraging minimal waste quantities.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Karen Trchounian
Affiliation: Yerevan State University
Country: Armenia

Short biography: Prof. Dr. Karen Trchounian graduated from Yerevan State University (YSU), Yerevan, Armenia in 2011. He obtained his PhD from YSU in 2013 and Doctor of Science degree in 2017. Currently, he is Director of Research Institute of Biology, Head of Research Laboratory of Microbiology, Bioenergetics and Biotechnology and Director of YSU Microbial Biotechnologies and Biofuel Innovation Center and holding professor position at the Department of Biochemistry, MIcrobiology and Biotechnology. He has visited Martin-Luther University of Halle-Wittenberg, University of Konstanz, Wageningen University and others for short and long term research stays. He has lectured in US, EU, Japan and other countries as invited lecturer. His main interests are Environmental regulation of bacterial growth and metabolism, hydrogenase activity and hydrogen production by bacteria, bioenergetics of fermentation, waste to biobased products technologies.

ENVIEN GROUP – Biofuels Production with Circularity and Sustainability

Klaudia KARKESZOVÁ, **Valentína KAFKOVÁ**
ENVIEN GROUP, Leopoldov, Slovakia, Karkeszova@enviengroup.eu

Abstract: ENVIEN GROUP represents a robust group of 16 companies dedicated to biofuels and their value chains, spanning eight countries in Central Eastern Europe. Since 2023, the group has expanded also to India. It holds a leading position in the biofuel industry within the CEE region. The core of the product portfolio is centred around the production of bioethanol from corn and biodiesel (FAME, fatty acid methyl esters) derived from vegetable oils and used cooking oil (UCO). ENVIEN GROUP places a strong emphasis on the circular economy and efficient valorisation of biorefinery by-products to maximize the full biomass-to-products value along the entire value chain. This approach results in valuable outputs such as animal feed (DDGS, rapeseed meal), post-fermentation corn oil for subsequent biodiesel production, glycerine, and utilization of biogenic CO_2. Since its establishment, facilities have consistently increased their production capacities, improved technological processes, and expanded both core activities and the product portfolio. Current research activities at ENVIEN GROUP are focused on producing value-added compounds and specialty chemicals from the by-products of biofuel production, including alternative protein isolate production from rapeseed meal and the separation of bioactive phytosterols from post-fermentation corn oil. Looking toward the future, ENVIEN GROUP is currently evaluating integrated biogas production, the potential for sustainable aviation fuel (SAF) production, waste-to-liquid processes for methanol synthesis, and alternative methods for ethanol valorization.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Klaudia Karkeszová
Affiliation: ENVIEN GROUP
Country: Slovakia

Short biography: My academic background includes a Master's degree in Biotechnology and a PhD. in Biochemical Engineering from the Slovak Technical University in Bratislava, Faculty of Chemical and Food Technology. Currently, I am positioned as an R&D Specialist at Envien Group within the Research and Development Center. From the company's product portfolio and activities, I specifically focus on the areas of biogas stations and biomethane production.

Eco-Friendly Synthesis of Lignin/Silica Bionanocomposites via Gas-Phase Modification Method

Liudmyla Nosach[1, 2], **Olena Sevastyanova**[1]

[1]*Department of Fibre and Polymer Technology, KTH-Royal Institute of Technology, Teknikringen 56-58, SE-100 44 Stockholm, Sweden, nosach@kth.se*

[2]*Department of Amorphous and Structurally Ordered Oxides, Chuiko Institute of Surface Chemistry, NAS of Ukraine, General Naumov Str. 17, 03164 Kyiv, Ukraine*

Abstract: Lignin, a byproduct of paper and pulp industries, poses a significant challenge for waste management, with an annual generation exceeding 500 thousand tons. While essential for operational processes like chemical recovery and energy generation, surplus lignin presents opportunities for value-added applications. However, effectively harnessing lignin as waste necessitates innovative end-of-chain strategies.

Lignin, a complex macromolecule derived from *p*-coumaryl alcohol, coniferyl alcohol, and sinapyl alcohol, holds substantial potential for integration into organic–inorganic composites. The creation of such composites offers a promising avenue for acquiring materials with superior properties, compared to their individual components, thereby opening up new possibilities across various applications. Particularly noteworthy is the combination of lignin, the second most abundant biopolymer after cellulose, with fumed silica.

The distribution of lignin, a complex three-dimensional network polymer (specifically, lignosulphonate DP-1962 from Sarpsborg, Norway), onto the surface of amorphous non-porous highly disperse silica (nanosilica, fumed silica with S_{BET}=300 m^2/g, from Kalush, Ukraine) presents a challenge that necessitates novel synthetic strategies. After years of research, the Chuiko Institute of Surface Chemistry of NAS of Ukraine has developed an environmentally friendly and technologically advanced method called gas-phase solvate-stimulated mechanosorption modification (GSSMSM) for modifying nanosilica with nonvolatile low- and macromolecular organic substances, as well as inorganic salts. This method was explored for applying complex three-dimensional biopolymer lignin onto the fumed silica surface in a gas dispersion medium.

A series of lignin/silica bionanocomposites, varying in biopolymer content (0.5, 0.75 and 1 layer), were synthesized using the GSSMSM method and thoroughly characterized using infrared spectroscopy, thermogravimetry, low temperature nitrogen adsorption-desorption, and scanning electron microscopy (SEM).

The degree of perturbation of silanol groups on the nanosilica particles surface, the main active sites, due to the formation of hydrogen bonds with polar functional groups of organic molecules, determines the degree of surface coverage. The degree of surface coverage of nanosilica with lignin molecules, calculated from the IR spectra, was approximately 65%. This incomplete perturbation of silanol groups on the nanosilica surface is attributed to the three-dimensional structure of the lignin molecule.

The results demonstrate the effectiveness of the GSSMSM method in immobilizing lignin onto the nanosilica surface, paving the way for the development of novel bionanocomposite materials. Furthermore, this method aligns with the principles of green chemistry and offers the prospect of obtaining tailored nanomaterials with specified characteristics suitable for a range of applications, including water treatment, biomedical applications, and functional fillers for polymer systems.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Liudmyla Nosach
Affiliation: KTH-Royal Institute of Technology, Stockholm
Country: Sweden

Short biography: PhD in Physics and Chemistry of Surface (2008), Chuiko Institute of Surface Chemistry NAS of Ukraine. Academic rank: Senior researcher (2016), Speciality Physics and Chemistry of Surface, Chuiko Institute of Surface Chemistry NAS of Ukraine. Current position: Researcher at KTH-Royal Institute of Technology, Sweden. Specialist in the field of surface chemistry with extensive research experience in processes of adsorption, chemical, polymerization and geometric modification of nanosilica with nonvolatile low- and macromolecular organic substances and inorganic salts under conditions of a regulated gas dispersion medium and liquid medium. Author of 152 scientific publications, including 56 articles and 4 patents.

Using MSW-derived biochar for real-world environmental applications – A review

Santa Margarida Santos[1,2], **Margarida Gonçalves**[2], **Paulo Brito**[1] **and Catarina Nobre**[1]

1VALORIZA, Research Center for Endogenous Resource Valorization, Polytechnic University of Portalegre, 7300-555 Portalegre, Portugal, margarida.santos@ipportalegre.pt, pbrito@ipportalegre.pt, catarina.nobre@ipportalegre.pt

2MEtRICs, Chemestry Department, NOVA School of Science and Technology, Campus Caparica, 2829-516 Caparica, Portugal, mmpg@fct.unl.pt

Abstract: In recent decades, the global generation of municipal solid waste (MSW) has increased constantly, and is expected to increase by 70% by 2050, reaching approximately 3.4 billion tons. The MSW stream comprises food and green waste, paper, cardboard, plastic, glass, metal, rubber, leather, wood, and miscellaneous materials. Converting this waste, which is often rich in organic carbon, into ecological biochar is a promising approach to the waste management sector. MSW-derived biochar has unique properties such as a high carbon content, high cation exchange capacity, large surface area, and stable structure. The aim of this study was to address the production of MSW-derived biochar and the routes for practical applications in the real world to create a supply chain, commercialization, and use of MSW-derived biochar. Despite the existence of several conversion technologies, pyrolysis is usually the preferred technology for converting MSW into biochar. Three different types of pyrolysis processes (slow, fast, and flash) and the average yields of biochar are described in this review. MSW-derived biochar has applications in wastewater treatment, soil remediation and correction, carbon capture and sequestration, adsorption of pollutants and contaminants, construction sector, as a catalyst, and fuel for energy production. Due to the distinctive compositions of MSW, the resulting properties of biochar often diverge. This review highlights the necessity of creating a standardization for each application, considering the characteristics and quality of each MSW-derived biochar. The critical characteristics of MSW-derived biochar routes for each group of applications are discussed, as well as the main advantages of using MSW-derived biochar in practical, real-world environmental applications.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Santa Margarida Santos
Affiliation: Polytechnic University of Portalegre and NOVA School of Science and Technology
Country: Portugal

Short biography: Santa Margarida dos Santos has a degree in Renewable Energy and Environment Engineering from the Polytechnic University of Portalegre and Master in Bioenergy from the NOVA School of Science and Technology. Has developed research work in Research Fellowships (PoliTechWaste and AmbWTE projects) in waste recovery, bioenergy, and renewable gases trough gasification. In terms of publications, she has 4 journal article, 6 conferences paper, 2 poster and 5 oral presentations. More recently she started her PhD in Bioenergy where she will study the valorization of Refuse Derived Fuels (RDF) through gasification to produce value-added products.

A review: The effect of vermicompost on plant growth, yield, quality and plant health

Margit Olle
NPO Veggies Cultivation, Tartu, Estonia, email: margit.olle@gmail.com

Abstract: Organic waste disposal from domestic, agricultural, and industrial sources has caused increasing environmental and economic problems in recent years, and many different technologies to address this problem have been developed. One possible way to handle big waste problem is vermicompost technology. This review specialises on the influence of vermicompost on the crop production. Vermicomposting is described as "bioxidation and stabilization of organic material involving the joint action of earthworms and mesophilic micro-organisms". Vermicompost is high in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipases, cellulase, and chitinase, and immobilized microflora. Vermicompost tea is a liquid vermicompost solution made by combining vermicompost with water and fermenting it for a set period of time. Vermicompost can be produced "on-farm" at a low cost using simple techniques, whereas chemical fertilizers are high-tech and expensive products produced in factories. Adding vermicompost to the soil influences positively soil environment: soil organic matter rises, soil content of beneficial microbes elevates, soil cation exchange capacity increases, the bulk density of soil decreases, which prevents soil compaction and erosion, reduction in soil-borne pathogens, rises water holding capacity, optimal pH value of soil maintains. Vermicompost and vermicompost tea improves germination, growth, biomass, and yield in plants. Vermicompost and vermicompost tea increased mineral nutrients in plants. Vermicompost and vermicompost tea also resulted in higher antioxidant activity and total phenolics in plants than synthetic fertilization. Vermicompost and vermicompost tea have been widely used for the management of plant diseases and pests. As a result, these organic fertilizers are regarded as viable alternatives to chemical pesticides and fungicides, and they should be used more frequently to prevent disease and ensure food security and safety.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). This investigation was carried through under project: „Improving cereal production technology". This inter-sectoral mobility grant received funding by the State Shared Service Centre (in Estonia) and by Aru Agricultural Ltd.

Details of presenting author

Name: Margit Olle
Affiliation: NPO Veggies Cultivation
Country: Estonia

Short biography: Margit Olle defended her doctor Scientiarum degree at Agricultural University of Norway in 1999. During the years 2000–2001 she was working on a post-doctoral project. From 2008 to 2020, she worked as a senior researcher at the Estonian Crop Research Institute. Since 2021, she has worked at NPO Veggies Cultivation. She has published 12 research monographs—books in English. She has been invited to speak in Estonia and around the globe, has got international awards, has organized conferences, and is a member of the editorial boards of international scientific journals. Margit Olle is vice president of CIEC (International Scientific Centre of Fertilizers).

Bark valorization through biorefinery technologies

Mariem Zouari[1], Kristine Meile[2], Faksawat Poohphajai[1], Marica Mikuljan[1], and Rene Herrera Diez[1]

[1]InnoRenew CoE, Izola, Slovenia, mariem.zouari@innorenew.eu

[2]Latvian State Institute of wood chemistry, Riga, Latvia

Abstract: The increasing demand to minimize the quantities of by-products generated by different processes has prompted investigation into effective biorefinery technologies for valorizing side streams. Bark is an abundant by-product of the forest industry, which is generated in large volumes. One way to manage bark and enhance its value is thermochemical conversion, specifically, slow pyrolysis. Slow pyrolysis process generates three different co-products with variable ratio depending on the pyrolysis conditions (i.e., temperature, time, heating rate). These three co-products consist of biochar, condensable, and non-condensable gas fractions. Biochar (with average yield ranging from 15% to 40%) is used in a wide range of applications given its interesting features such as large porosity and surface functionality. However, the gas fraction (up to 60%) is usually wasted. The condensable gas fraction is recovered through condensation in water making a significant amount of liquid side stream called pyrolysis liquid. This study aimed to enhance the effectiveness and profitability of slow pyrolysis process through biorefinery by utilizing the biochar and exploring the anti-fungal potential of pyrolysis liquid. Softwood bark material was pyrolyzed (800 °C for 30 min) under nitrogen atmosphere. Firstly, the obtained biochar was characterized by physisorption, proximate, and FTIR analyses. The biochar was evaluated for its efficiency in air depollution through volatile organic compounds adsorption tests. Secondly, four pyrolysis liquid fractions were collected at different temperature ranges. The liquid fractions were characterized by FTIR and high-performance liquid chromatography. The total phenolic content of the samples was determined by titration. The anti-fungal activity of the fractions was investigated using diffusion test in the presence of two different fungal species: Cladosporium pseudocladosporioides and Penicillium sp. Results will be presented and discussed.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). This research was financially supported by the ForestValue Research Program and the Republic of Slovenia’s Ministry of Higher Education, Science, and Innovation [BarkBuild: grant agreement No C3330-21-252003].

Details of presenting author

Name: Mariem Zouari
Affiliation: InnoRenew CoE
Country: Slovenia

Short biography: I am an assistant researcher at InnoRenew CoE and a PhD student at the Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska. I graduated from a bachelor’s degree in applied biotechnology from the Higher Institute of Biotechnology of Sfax (Tunisia) and a professional master’s degree in food sciences and technologies at the same institution. I then completed an engineering master’s program in food biotechnology at Szent Istvan University (Budapest, Hungary). My doctoral studies project focuses on the development of photocatalytic biocarbon-containing coatings for adsorption and photodegradation of volatile organic compounds in the indoor environment.

Biomass waste thermochemical treatment to achieve safe utilization and valorisation aims

Maris Klavins, Linda Ansone-Bertina, Lauris Arbidans
Department or Environmental Science/University of Latvia, Riga, Latvia, maris.klavins@lu.lv

Abstract: Need to mitigate climate change requires to refuse from extensive use of fossil fuels and develop biomass-based development model – bioeconomy. Processing of agricultural, forestry and other origin biomass leaves significant amounts of biomass side streams which should be safely utilised or transformed into energy or added value products. Thermochemical processing of biomass side streams offers great potential for bioeconomy and can help to achieve environmental, and energy aims and develop new products to replace fossil material-based products. Thermochemical processing of biomass side streams thus can reduce or even eliminate the greenhouse gas emissions into the atmosphere and thus are essential to create technologies that not only benefits the economy (power generation, chemical industry) but are also environmentally friendly (carbon neutral or even negative).

The aim of this study is to advance biomass waste thermochemical processing technology by studying and optimizing it. Another aim is to study obtained biochar potential application possibilities as sorbent for CO_2 sorption – carbon capture.

Widely available types of waste material such as straw, peat mining and processing wastes, wood processing wastes, manure, aquatic biomass etc. has been tested as a source of biochar. Dependence of the porosity and other significant properties of biochar on initial feedstock, conditions of preparation as well as role of the addition of activation additives during the process have been studied and optimal feedstock and conditions are defined. Also Hydrothermal Carbonisation (HTC) offers a sustainable and cost-effective solution for thermochemical processing of biomass and development of new products from biomass side streams through resource recovery. This process involves wet biomass treatment at elevated temperatures (180 – 260 C) and pressure with/without catalyst to destroy or solubilize biomass wastes. Hydrothermal carbonization is a thermochemical conversion technique which uses subcritical water as a green reaction medium to carbonisation of biomass. During HTC takes place the conversion of wet biomass to carbonaceous products - hydrochar with high oxygenated functional group content which makes it an effective precursor to produce chemically activated carbon, biochar and other applications. As during HTC process biomass carbon is converted to biologically less accessible form, this technology may be considered as belonging to carbon capture and storage technologies. Even more, this process seems to be prospective for the solution of the number of other global environmental problems. We have demonstrated that besides to hydrochar also alkaline soluble organic macromolecules are formed – artificial humic substances (AHS). Artificial humic substances obtained in hydrothermal carbonisation process have functionalities characteristic for natural humic substances – natural component of soils. AHS shows ability to form clay-humin complexes, that are responsible for water and nutrient binding in fertile natural soils. Although the impact of artificial humic substances on soil fertility are still not proved, it is already possible to speak about the perspectives to use AHS as soil conditioner. Yields and carbon stabilisation efficiency of this process are many times higher than characteristic for both: natural humification and pyrolysis. Therefore, it is possible to state, that the incorporation of HTC

amongst the processes that will be used in soil-oriented climate solutions together with hydrochar could be much more efficient than biochar mixtures with compost and other possible alternatives. Non-agricultural application of artificial humic acids, e.g., use in environmental technologies as well must be considered and analysed in the future. Considering highly prospective application potential, the properties of artificial humic substances in comparison with fossil material humic substances as well as their dependence on biomass type has been studied.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Maris Klavins
Affiliation: University of Latvia
Country: Latvia

Short biography: Major research fields are in environmental pollution and its chemical analysis, aquatic chemistry, sustainable management of wastes and bioeconomy. In last few years M. Klavins has been involved in development of legislative system of environmental protection in Latvia regarding monitoring system, chemical substances, chemical safety, toxic wastes and especially is doing with the problems of analysis of environmental pollution. M.Klavins has been leader of several projects related to the environmental issues mostly doing with environmental pollution and management and quality of water, but including also political and social sciences.

Industrial Waste Valorization into Functional Polymers

Marta Goliszek[1], **Maria Kochaniec**[2], **Beata Podkościelna**[1]
[1] Institute of Chemical Science, Faculty of Chemistry, Maria Curie-Skłodowska University, Lublin, Poland, marta.goliszek@mail.umcs.pl, beata.podkoscielna@mail.umcs.pl
[2] Chemical Faculty, Warsaw University of Technology, Warsaw, Poland, maria.kochaniec@pw.edu.pl

Abstract: The use of renewable carbon sources as a substitute for fossil resources is an extensively essential and fascinating research area for addressing the current issues related to climate and future fuel requirements. The use of renewable and sustainable resources is required for cleaner production by minimizing greenhouse gas emissions and waste. It is valuable to search for new formulations aimed at the production of functional polymer materials containing components of natural origin and the tailored functional properties. Lignin is the most abundant aromatic polymer found in nature. It is a waste product from industrial processes, mainly the paper and pulp industry, where small amounts are used as a low-value energy source. The recent emergence of biorefineries has resulted in the production of further lignin with no obvious route for valorization. What also deserves attention is the utilization of fly ashes. Fly ash, generated during the combustion of coal for energy production, is an industrial by-product which is recognized as an environmental pollutant. Because of the environmental problems presented by the fly ash, considerable research has been undertaken on the subject worldwide. In this research work, various aspects of the use of lignin as industrial waste and fly ash for the synthesis of functional polymeric materials were discussed in detail.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Marta Goliszek
Affiliation: Maria Curie-Skłodowska University in Lublin
Country: Poland
Short biography: Marta Goliszek, an assistant professor at Maria Curie-Skłodowska University in Lublin, Poland, holds a Ph.D. in polymer chemistry. Her extensive research portfolio covers various aspects of biomass conversion, lignin valorization, synthesis of bio-based polymer composites, microspheres and lignin-based materials. Her current research work focuses on the significant issue of sustainable solid waste management through the promotion of safe practices and effective technologies, aiming to accelerate the transition to the circular economy.

Sustainable adsorbents from agricultural wastes: rice husk-based composite materials for heavy metals removal from wastewater

Michela Alfe[1]*, Valentina Gargiulo[1], Francesco Di Natale[2]
[1] *CNR – STEMS, Institute of Sciences and Technologies for Sustainable Energy and Mobility, Naples, Italy*
[2]*University of Naples "Federico II", Naples, Italy*
**michela.alfe@stems.cnr.it*

Abstract: Agroindustry generates huge amounts of residues every year (about five billion metric tons in 2020–2021) and their recycling as raw materials is an attractive strategy to reduce waste disposal and globally increase energy savings and cost reduction of the whole waste disposal chain. The development of approaches for the recycling and/or reuse of wastes generated by the industrial processing of agricultural raw materials is an issue that is attracting increasing attention. Low-cost adsorbents can be prepared by utilizing abundant and inexpensive agricultural wastes that are characterized by high organic and low inorganic contents and are easily activated. Examples of raw agricultural wastes successfully used for the preparation of carbon-rich adsorbents include coconut shells, cotton stalks, sugarcane bagasse, coir pith, straw, rice husk, sawdust, coconut husk, oil palm shell, neem bark, peanuts, olive wastes, almond shells, apricots and cherries stones and wastes resulting from the production of cereals.

In this work, a series of materials derived from carbonized rice husk was prepared and tested as sorbents for the removal of target heavy metals from aqueous solutions at different pH values. Copper and lead ions have been chosen because they are present in a wide number of industrial and civil wastewaters and their removal remains a critical issue for many applications. To study the effects of adsorbent composition, surface chemistry and textural properties on heavy metal ions adsorption, the carbonized rice husk was used as it is, after water washing and after a desilication treatment. Moreover, the carbonized rice husk and its desilicated form were also used to produce composite materials by coating with iron oxide particles up to 10 wt.%. All the adsorbents were fully characterized and their adsorption performances toward copper and lead ions have been evaluated by probing different metal ion concentrations, temperatures, and pH values. The adsorption data have been also modelled by an additive-competitive Langmuir model. The results highlighted that all the investigated materials exhibited a higher affinity towards leads ions, in line with previous literature results on similar materials. In all the cases, the adsorption of both metal ions between pH 4 and 6 was optimal, while a lower absorption has been found in the case of solutions at pH 2. It is worth of noting that in the case of the composite materials (specifically desilicated carbonized rice husk covered with iron oxide nanoparticles) a synergism between the two phases is achieved leading to better adsorption performances towards both copper and lead ions. Additionally, the presence of iron oxides in the form of magnetite (Fe_3O_4) makes the materials magnetically reactive allowing an easy recovery after use. The results obtained are very promising and the proposed synthetic approach could represent a feasible route to produce low-cost adsorbent for heavy metal ions removal by the valorisation of very abundant agricultural wastes such as rice husk.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Michela Alfe
Affiliation: CNR-STEMS
Country: Italy

Short biography: Michela Alfe is a CNR (National Research Council) senior researcher at the Institute of Science and Technology for Sustainable Energy and Mobility (STEMS). She holds a degree in chemistry and a PhD in chemical engineering. Her highly inter - or multidisciplinary activities are focused on two strategic areas, Energy and Environment and Materials Science, and include the valorisation of end-of-life materials and the synthesis of innovative materials for applications in energy processes (solid sorbents for CO_2 capture and storage, water treatment, sensoristic, photoactive materials).

Properties of Hybrid Composites Filled with Lignin and Cellulose Fibers

Mykola Melnychuk[1], Nina Polivoda[1], Igor Shevchuk[1]
[1]*Department of materials science, Lutsk national technical university, Lutsk, Ukraine, m.melnychuk@lntu.edu.ua*

Abstract: The world industry produces 100 million tons of PP annually, and if at least 30% of the polymer were replaced with natural components, it would reduce oil consumption by a third, as well as the embodied energy used to produce PP.

The hybrid composites based on a polymer matrix and a natural (renewable) filler can be one of the alternatives to widely used polymers. It is well known that natural fillers have poor adhesion to hydrophobic polymer matrices. In order to improve the interaction between hydrophilic fillers and hydrophobic matrix, fillers are usually pre-treated with activators. The grafting of lignin and PP can be cost-effective and will have a positive impact on the carbon footprint and the environment in general. So, the process of developing hybrid composites should take into account the interfacial compatibility and dispersion of the material components.

Composites made by injection molding based on polypropylene and Kraft-lignin, microcellulose from hemp waste with filling from 9 to 27 wt % were investigated in the work. In order to enhance the adhesion between the filler and the polymer, a special chemical treatment of the components was used with the addition of talc as a compatibilizing agent. Tensile and bending tests of the composites were carried out, as well as studies on the determination of microstructure features and evaluation of the influence of reinforcement and homogenization of mixtures using SEM. It was established that, compared to primary polypropylene, the flexural strength of composites with microcellulose practically did not change, the Young's modulus (E) increased to 12% depending on the degree of filling, and the flexural strength of composites with lignin increased to 42.3 MPa (32%), E up to 1570 MPa (22%). The tensile strength is practically unchanged for the cellulose filler, and slightly increased to 10% for lignin, and the Young's modulus, depending on the type of filler and degree of filling, increased from 10 to 32%. Structure studies indicate a good inter phase interaction of components in composites. As a result, it can be stated that lignin in the composition of hybrid composites has good prospects for replacing the exhaustible resource from which polypropylene is polymerized. Of course, further research is needed, as the results could be affected by unsystematic dispersion, but the perspective of using lignin in composites has been proven. In future studies, we have to study how a larger amount of lignin will affect the composite, as well as heat resistance, UV resistance, water absorption, and so on.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Mykola Melnychuk
Affiliation: Head of department materials science, Lutsk national technical university
Country: Ukraine

Short biography: CURRENT Lutsk, Ukraine UNIVERSITY DEPARTMENT HEAD**,** LNTU. CURRENT Kyiv, Ukraine. EXPERT NATIONAL AGENCY FOR QUALITY ASSURANCE IN HIGHER EDUCATION OF UKRAINE. Examination of educational programs in the field of Mechanical Engineering; management of international activities of the Faculty of Technology. SENIOR LECTURER, LNTU: teaching courses "Materials Science", "Materials from renewable sources" "Sustainable development for engineers". DESIGN ENGINEER COMPANY "BOGDAN MOTORS"

Enhancing Anaerobic Digestion Efficiency and Digestate Safety Through Sludge Pre Ozonation

Shengkun Dong[1], Roaya Hammoudy[2], Bayan Hamdan[2], Nedal Massalha[2*]

[1] School of Civil Engineering, Sun Yat-sen University, Guangzhou, China, sdong6@outlook.com

[2] The Institute of Applied Research, Galilee Society, Shefa-Amr, Israel, nedal@gal-soc.org

Abstract: Anaerobic digestion stands as a pivotal process for organic waste treatment, offering dual benefits of chemical oxygen demand (COD) reduction and nutrient recovery via digestate recycling. Nonetheless, optimizing anaerobic digestion efficiency and ensuring digestate safety remain paramount objectives in waste biorefinery technologies for sustainable energy processes. This study delves into the efficacy of sludge pre-ozonation to augment methane production while mitigating sludge cytotoxicity and estrogenicity during anaerobic digestion.

The investigation scrutinized the impact of sludge pre-ozonation on methane production and toxicity parameters, focusing on sludge with varying volatile solid (VS) values. Results unveiled a notable enhancement in methane production potential (up to 36.5%) and rate (up to 69.2%) with post-partial digestion ozonation. Moreover, the modulation of sludge cytotoxicity and estrogenicity exhibited improved outcomes with sludge ozone pretreatment, showcasing maximum reductions of 28% and 23%, respectively, particularly in sludges with lower VS values.

The conclusions drawn from bench-scale batch anaerobic digestion experiments underscore several key insights. Firstly, the efficiency of sludge disintegration and cell lysis via ozone treatment was more pronounced in samples with lower VS values, advocating for post-partial digestion ozonation for optimal methane generation. Secondly, the control of digestate toxicity was notably enhanced with sludge ozone pretreatment, particularly beneficial for sludges pre-digested to lower VS values. Lastly, to achieve maximal methane production while concurrently minimizing sludge toxicity, a sequential approach involving partial digestion, sludge ozone pretreatment, and final anaerobic digestion is recommended.

This research contributes significant implications for waste biorefinery technologies, offering a nuanced understanding of how sludge pre-ozonation can enhance anaerobic digestion efficiency and digestate safety. The findings pave the way for informed strategies in waste treatment processes, aligning with the imperative goal of accelerating sustainable energy processes through innovative waste biorefinery approaches.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Nedal Massalha
Affiliation: The Institute of Applied Research, Galilee Society
Country: Israel

Short biography: Massalha is currently the scientific director and a senior researcher at The Institute of Applied Research of the Galilee Society and a lecturer at Kinneret College. He earned his B.Sc. from The Department of Agriculture Engineering, M.Sc. from the Department of Civil and Environmental Engineering of the Technion, and Ph.D. from the Department of Environmental Engineering of Ben-Gurion University Israel. Massalha Joined the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign, USA, as a postdoctoral research associate. His research focuses on 1) Environmental health risks associated with the reuse of wastewater and biosolids; 2) Enhancing bioenergy recovery and water treatment processes.

Hydrogen-rich gas production from single-use waste plastics

N. Striūgas, K. Zakarauskas, J. Eimontas
Laboratory of Combustion Processes, Lithuanian Energy Institute, Kaunas, Lithuania, nerijus.striugas@lei.lt

Abstract: The unanticipated occurrence of the COVID-19 pandemic has resulted in unmanageable levels of single-use plastic (SUPs) waste (including disposable face masks, gloves, protective medical suits, facemask shields, takeout plastics, food and polyethene goods packages, and medical test kits). Although official statistics on SUPs waste generation are not yet available, there are a number of scientific studies that estimate this increase. For example, it can be predicted that up to ~4.5 tons per day of SUPs medical mask waste may be generated in Lithuania alone. At first glance, this seemingly small amount of waste should not be a major problem. However, recent reports indicate that used masks have entered the marine environment, leading to significant pollution increases in recent years. That's why it can be noted some masks are not properly utilized. It is thought that the masks may be one source of harmful microplastic fibres in the land, in water, or in the litter. Creating a safe collection system for these masks, such as installing special collection bins at certain locations, used COVID-19 face masks could be recycled into more valuable products such as hydrogen.
The aim of this study is to adapt a small-scale downdraft-moving bed gasification reactor for the gasification of mixed face masks in oxygen and oxygen/steam environments. Study shows that the optimum gasification temperature for obtaining the maximum H_2 content in syngas is 900 C, and the ER is 0.19. The catalytic steam conversion of the hydrocarbons present in the gaseous products results in a greater than 99,9 % conversion of the resins using Ni-containing catalysts. With zeolite catalysts, this conversion is only 40 %, but the tars contain a higher proportion of benzene and toluene, which account for around 70 % of the total compounds. After catalytic conversion, the maximum H_2 content in the gaseous products was 59,3 % vol.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Nerijus Striūgas
Affiliation: Laboratory of Combustion Processes, Lithuanian Energy Institute
Country: Lithuania

Short biography: In 2009, the author defended his PhD thesis in the field of gasification of liquid wastes in order to produce hydrogen rich gases. He has continued his career by deepen his knowledge in biomass and waste gasification, pyrolysis and combustion, thermochemical conversion and synthesis of the resulting products by implementing various national or international projects, internships or supervising PhD students. Since 2011, he has been leading a research group in this field.

Solar Hydrothermal Liquefaction Technology Developmental Path

Nikolaos I. Tsongidis[1], **Charikleia A. Poravou**[2], **Christodoulos Lekkos**[3], **George Karagiannakis**[4]

[1]Centre for Research & Technology Hellas (CERTH)/Collaborating Researcher, Thessaloniki, Greece, ntsongid@certh.gr
[2]Centre for Research & Technology Hellas (CERTH)/Research Engineer, Thessaloniki, Greece, cporavou@certh.gr
[3]Centre for Research & Technology Hellas (CERTH)/Research Engineer, Thessaloniki, Greece, lekkos@certh.gr
[4]Centre for Research & Technology Hellas (CERTH)/Principal Researcher, Thessaloniki, Greece, gkarag@certh.gr

Abstract: Hydrothermal liquefaction (HTL) is a thermochemical technology that mainly converts wet (highly moist) biomass into added value products, with the main product being a dark, viscous, oily phase (biocrude). Although the technology was first introduced in the early 1970s after the 1973 Oil Crisis, it has recently reattracted research interest due to fossil fuels depletion, biomass treatment demand and the worsening climate crisis [1]. In HTL, water near its sub-/super- critical conditions (374^{o}C, 221 bar) acts at the same time as a reactant, a solvent and a catalyst due to the change of its dielectric and ionization constant respectively, leading to overall reactivity enhancement [2]. In general, the applied conditions lie within the range of 250-550^{o}C and 5-25 MPa, which are ideal conditions for the introduction of concentrated solar thermal (CST) technologies as the heating means of the HTL process [3]. The current work presents the developmental path followed by CERTH which is focused on the gradual introduction of concentrated solar thermal power to cover the thermal needs of the HTL main process, starting from conventional, lab-scale heating means (electrical heating) and expanding up to on-field testing with concentrated solar thermal power, in the scale of an automated, semi-pilot unit employing parabolic trough collectors able to operate in the range of 350^{o}C. Introduction of artificial light in an in-house solar simulator is given as an intermediate step between lab and on-field testing [3,4]. As a given example, the results of an indicative agri-food 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 in all cases when concentrated solar energy is introduced, which is largely attributed to the faster heating/cooling rates achieved.

References

[1] Wikberg H. et al., Biomass and Bioenergy 14 (2015), 195–207.
[2] Elliott, D.C. et al., Algal Res. 2(4) (2013), 445-454.
[3] Poravou C.A. et al., Waste Biomass Valorization 13 (2022), 9, 3835–3844.
[4] Tsongidis N.I. et al., AIP Conf. Proc. 2303 (2020), 170015.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Dr. Nikolaos I. Tsongidis
Affiliation: Collaborating Researcher
Country: Greece

Short biography: Dr. Nikolaos Tsongidis (MEng ChE, PhD, Aristotle University of Thessaloniki), is a Collaborating Researcher at CPERI/CERTH. His research interests mainly focus on solar thermochemistry technologies, including synthesis and evaluation of inorganic materials and reactors, biomass conversion into added-value products as well as computational simulation of chemical processes and materials design. He has prepared, participated and/or managed over 10 national and EU research projects, and has authored or co-authored 14 peer-reviewed publications *(h-index: 8)* with over 30 attendances in international conferences and workshops.

Is energy from biomass environmentally friendly?

Nurinisa Esenbuga

Department of Animal Science, Faculty of Agriculture, Ataturk University, Erzurum, Turkey
esenbuga@atauni.edu.tr

Abstract: As a result of the greenhouse effect caused by the gases released into the atmosphere by human beings, the rise in temperature on the earth's surface is defined as global warming. Global warming and the resulting global climate change are among the most important problems faced by the world in recent years and threaten the lives of all living things in the world. To reduce the speed of global warming, many countries trying to reduce greenhouse gas emissions are turning to biomass. Many countries around the world are making plans to produce more biomass energy. Today, about half of the renewable energy produced in Europe consists of biomass. Experts predict that biomass energy production will increase in the future. However, whether the use of biofuels actually reduces greenhouse gas emissions is a matter of debate. Although biomass is seen as an environmentally friendly energy source, scientific studies indicate that this is not true. Biomass is the materials that result from the growth of microorganisms, plants, and animals. All of these materials contain carbon. Therefore, when they are used as fuel, carbon dioxide is released into the atmosphere. Carbon dioxide is a greenhouse gas and the main cause of global warming is the increase in the amount of carbon dioxide in the atmosphere as a result of human activities. So how can energy from biomass be environmentally friendly? Theoretical predictions show that it takes a very long time to see benefits from biomass energy. Because the biomass, which would take months or even years to be decomposed by microorganisms and mixed into the atmosphere if left to its own state in nature, causes an increase in the amount of carbon dioxide in the atmosphere in the short term. Those who think that biomass is environmentally friendly today assume that the carbon dioxide released into the atmosphere during the production of energy from biomass is instantly consumed by plants. However, scientific studies do not confirm this assumption.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Nurinisa Esenbuga, Prof. Dr.
Affiliation: Ataturk University
Country: Turkey
Short biography: Dr. Nurinisa Esenbuga is a Professor of Animal Breeding at the Department of Animal Science of Ataturk University in Turkey. She has M.Sc. (1995) and Ph.D. (2000) degrees from the Department of Animal Science of Ohio State University as a post-doctorate. She is the author of more than 112 scientific papers and a member of the editorial board of various scientific journals. Dr. Esenbuga's research has been focused on Animal Breeding and Genetics. Science. Since 1992 she has continued her research and teaching activities. She had studied at the Department of Animal.

Unlocking the value of lignin: transforming pulp industry by-product into advanced nanomaterials for sustainable applications

Olena Sevastyanova[1], **Taoran Xu**[2] **and Oihana Gordobil**[3]

[1]*Department of Fibre and Polymer Technology, KTH Royal Institute of Technology. Stockholm, Sweden, olena@kth.se*

[2]*WWSC Wallenberg Wood Science Center, Department of Fibre and Polymer Technology, KTH Royal Institute of Technology, Stockholm, Sweden, taoranx@kth.se*

[3]*Department of Chemical and Environmental Engineering, University of the Basque Country (UPV/EHU), San Sebastian, Spain, oihana.gordobil@ehu.eus*

Abstract: Lignin, a bio-origin aromatic macromolecule, is an abundant yet underutilized by-product of the pulp industry, primarily due to challenges associated with its complex isolation and modification processes. Recent advances in fractionation, chemical modification, and nanoparticle assembly techniques have paved the way for the development of lignin-derived materials with potential applications across diverse fields, including polymers, cosmetics, drug delivery systems, and environmental pollution treatment. The intrinsic properties of lignin, such as its antioxidant capacity and biodegradability, render it an ideal candidate for sustainable additive manufacturing.

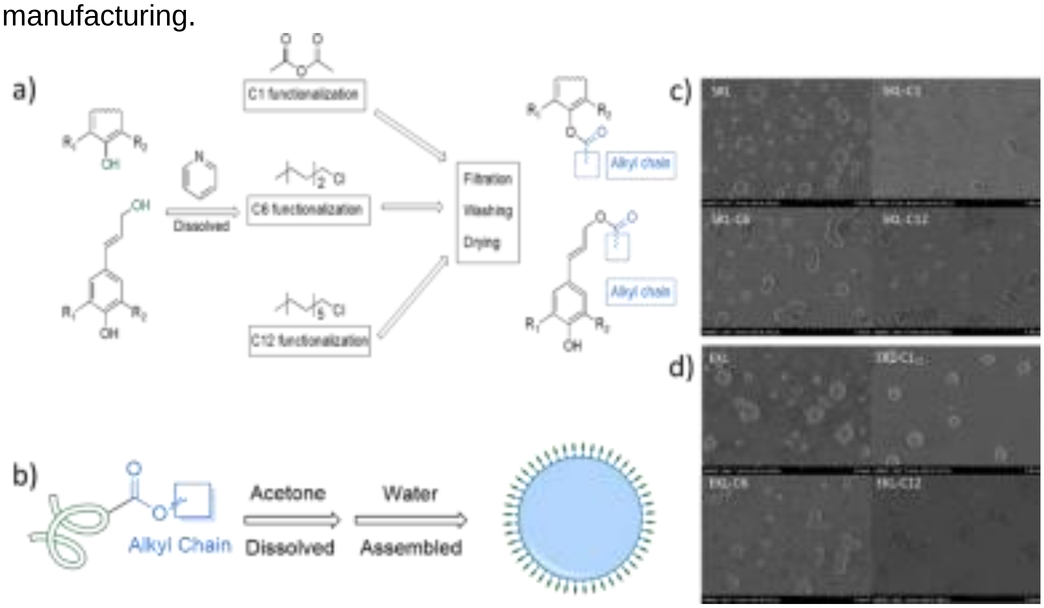


Figure 1. Schematic representations of a) chemical modifications of spruce (SKL) and eucalyptus (EKL) kraft lignin samples (where R1= H or -OCH3, R2= -OCH3) and b) of the synthesis of lignin nanoparticles and scanning electron microscopy (SEM) images of LNP's made of c) spruce and d) eucalyptus lignin samples.

This study focuses on the impact of modifying lignin with fatty acids of varying alkyl chain lengths on the self-assembly process of lignin nanoparticles (LNPs) via the solvent exchange method (Fig. 1a, b). Our findings reveal that the incorporation of longer alkyl chains enhances water repulsion, consequently leading to a reduction in LNP size (Fig.1c, d). This observation underscores the significant role of chemical functionalization in dictating the morphology and potential applications of LNPs.

Utilizing spruce and eucalyptus kraft lignins (SKL and EKL), this research employs esterification reactions with acetic acid anhydride, hexanoyl chloride, and dodecanoyl chloride to attach alkyl groups with three distinct chain lengths (C1, C6, and C12). The selective modification observed among the aliphatic and phenolic hydroxyl groups within lignin, facilitated by the structural stereology and thermodynamics of the reactions, points to a nuanced control over the esterification process. The assembly of LNPs through the solvent exchange method, particularly with esterified Kraft lignins, demonstrates a direct correlation between alkyl chain length and nanoparticle diameter, with longer chains promoting smaller sizes.

This study not only sheds light on the parameters influencing the self-assembly and morphology of LNPs but also illustrates how the degree of chemical functionalization can be strategically manipulated to optimize the self-assembly behaviours and morphologies of LNPs, thereby broadening their application spectrum in sustainable technologies.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). O.G. acknowledges the financial support from the Spanish Research Agency (AEI) (RYC-2021-031328-I) funded by MCIN/AEI/ 10.13039/501100011033 by “European Union NextGenerationEU/PRTR”. O.S. and T.H. acknowledge funding from the Knut and Alice Wallenberg Foundation (KAW) through the Wallenberg Wood Science Center (WWSC 3.0: KAW 2021.0313).

Details of presenting author

Name: Olena Sevastyanova
Affiliation: KTH Royal Institute of Technology
Country: Sweden

Short biography: Dr. Olena Sevastyanova, an Associate Professor (docent) in Fibre and Polymer Technology at KTH, Sweden, is an expert in wood chemistry, pulp technology, and bio-based materials. She has published 85 peer-reviewed scientific papers and has an H-index of 32. Dr. Sevastyanova serves as the vice-director of the National Resource-Smart Processes (RSP) industrial research school. She has mentored 12 licentiate and doctorate students. Her current projects include doctorate projects within the RSP initiative, a Knut and Alice Wallenberg (KAW) foundation-funded proof-of-concept project on bio-based polymers for Li-ion batteries, on nanolignin materials, and on microfibrillated lignocellulose material for energy and environmental applications.

Kraft Lignin Valorization for Carbon in Energy Storage Systems

Omid Hosseinaei
RISE Research Institutes of Sweden, Stockholm, Sweden, omid.hosseinaei@ri.se

Abstract: Valorization of all streams of biorefineries is essential for biomass valorization and transition from petroleum-derived materials/energy to sustainable materials/energy. Lignin is the second most abundant natural polymer in plants' cell walls and the main side-stream of biorefineries. The kraft process is the dominant pulping process and the main source of industrial lignin. Lignin is an attractive carbon precursor due to its renewable source, low cost, and high carbon content. The fast-growing demand for energy storage devices created a unique opportunity for lignin as a bio-based carbon precursor. The energy storage industry uses different types of carbon, and an abundant and sustainable source of carbon can help to reduce the carbon footprint of this industry. We used a high-purity kraft lignin from the LignoBoost process for producing carbons. We studied the carbonization of lignin and the production of different forms of lignin-based carbons for anode electrodes in Li- and Na-ion batteries, and electrodes in supercapacitors. The properties of the precursor, the morphology of the carbons, and conversion parameters can impact the properties of the resulting carbon and its performance. These parameters and additional post-treatments of the carbons are important for producing carbons tailor-made for a specific application. In addition, the impact of different parameters on the structure of lignin-based carbons will be presented.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Omid Hosseinaei
Affiliation: RISE Research Institutes of Sweden
Country: Sweden
Short biography: Omid Hosseinaei, a senior researcher at the RISE Research Institutes of Sweden, holds a Ph.D. in natural resource engineering from the University of Tehran, Iran. His extensive research portfolio covers various aspects of biomass conversion, lignin valorization, bio-based composites, lignin-based materials, thermoplastics, and carbons. With specialized expertise in biomass/lignin carbonization, he has extensive experience in developing a wide array of carbon materials for both structural and non-structural applications. His ongoing research focuses on the development of sustainable polymers and carbon materials for applications in composites and energy-related fields, particularly in battery technologies.

Chemical recycling of plastic waste fractions for closing the material loop and increasing resource efficiency

Panagiotis Evangelopoulos[1]*, **Hoda Shafaghat**[1], **André Selander**[1], **Ann-Christine Johansson**[1]

1Department Biorefinery and energy, RISE Research Institutes of Sweden AB, SE-941 28 Piteå, Sweden
**Corresponding author: panagiotis.evangelopoulos@ri.se*

Abstract: Polymers are serving numerous applications of critical importance for the society. These include supply and storage of clean drinking water, packaging that reduces food wastage, clothing and footwear, building material, products for use in public health applications, electronics that are essential for all sectors. Unfortunately, with great societal benefits, polymeric materials also pose major problems for sustainability, as a huge amount of natural resources (mostly fossil) is spent on their production, and the lack of an effective system for their recycling leads to poor collection and littering of the environment. These problems are now well recognized, and society is making efforts to resolve them. In particular, the production of polymers from renewable materials is being developed, attempts to clean the ocean from plastics are being made, and much attention is being paid to recycling of end-of-life polymer products. Major investments and research efforts are being made to improve the mechanical recycling of polymers. However, at the current level of development, 87 % of material value is lost after the first use and a huge amount of processed raw material is removed from the production cycle and lost instead of being recycled into new products [1].

A range of chemical/thermochemical processes, often referred to as chemical recycling methods, give a possibility to recycle polymers at the molecular level by converting them into hydrocarbon products (syngas and oils) that can replace primary fossil raw materials in future use. The development of such "molecular" recycling is a key for closing the loop for all “problematic” polymer flows that are rejected from mechanical recycling.

There are several projects that RISE has led regarding chemical recycling of plastic waste fractions. Plastic packaging constitutes a major material loss for modern societies. Only in 2019, 1,3 million tons of plastic packaging has been introduced in Sweden and only 10% has been effectively treated for material recycling [2]. On the projects that RISE has focused together with industrial partners was to recover monomers from plastic waste packaging through HTL process. The recovery of specific monomers such as DMT and Bisphenol A has reached up to 90% recovery [3]. Waste electrical and electronic equipment (WEEE) is the fastest growing waste fraction, with 4,9 million tons collected for EU for 2021. The recycling of plastics derived from this fraction is challenging since they contain high amount of flame retardants. RISE has led a project aiming for production of BTX hydrocarbons by catalytic fast pyrolysis [4]. Other waste fractions with high plastic content that chemical recycling is promising method for increasing their recovery is fiber reinforced plastics (FRPs). Thermochemical methods can liberate the organic part while on the same time preserving the woven structure of the fibers resulting in a resource efficient recycling of FRPs.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Panagiotis Evangelopoulos
Affiliation: RISE Research Institutes of Sweden AB
Country: Sweden

Short biography: Dr. Panagiotis Evangelopoulos is graduated in Chemical engineering diploma from National technical University of Athens, he holds a MSc in Sustainable Technology from Royal Institute of Technology (KTH) and has received his PhD in the field of Material Science and Engineering from the Royal Institute of Technology (KTH) in the field of thermochemical processes for plastic derived from WEEE fractions. He is working as Researcher in the field of thermochemical processes (pyrolysis, HTL, gasification) at RISE leading projects related to resource efficiency, material recovery and sustainable waste management.

LIFE BIOAs project in Portugal: the opportunity of olive pomace biochar for arsenic adsorption

Paulo Mourão[1,2], Carolina Assis[2], Francesca Pagnanelli[3]

[1]MED – Mediterranean Institute for Agriculture, Environment and Development & CHANGE – Global Change and Sustainability Institute, Departamento de Química e Bioquímica, Escola de Ciências e Tecnologia, Universidade de Évora, 7000-671 Évora, Portugal, pamm@uevora.pt

[2]VALORIZA - Research Center for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, Portugal, carolina.assis@ipportalegre.pt

[3]HTR - High Tech Recycling Research Center (HTR), Dipartimento di Chimica, Sapienza Università di Roma, Piazzale Aldo Moro 5, 00185, Rome, Italy, francesca.pagnanelli@uniroma1.it

Abstract: One of the oldest biorefining processes begins in the Mediterranean with the production of olive oil. This process has evolved and become more efficient, but it still generates large amounts of waste in the form of olive pomace, which urgently needs to be exploited and valorised. In this context, the LIFE BIOAs project was launched with Italian and Portuguese partners to demonstrate the environmental and economic feasibility of a process for the production of an innovative bioadsorbent to be used for the purification of drinking water from arsenic and other pollutants. This work presents the results obtained with the use of this innovative bioadsorbent at 3 representative sites (Vila Flor, Ferreira do Zêzere and Ponte de Sor, in the north, centre and south of Portugal respectively) where, for natural or man-made reasons, surface or groundwater has concentrations well above the 10 µg/L limit set by European legislation (Directive 98/83/EC). The bioadsorbent has been produced through an innovative process of hydrothermal carbonisation of olive pomace (a by-product of the olive oil production industry) at a cost that is at least 50% lower than the conventional adsorbent used, GFH (granular ferric hydroxide). In addition, the portable water treatment unit, which is self-sufficient in terms of energy and was used in the field tests, will be presented.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). The actions carried out in the LIFE BIOAs project contribute to the implementation of the UN Sustainable Development Goals 6, 9 and 12 of the 2030 Agenda. The LIFE BIOAs project has received funding from the LIFE Programme of the European Union (LIFE19 ENV/IT/000512) with a Total budget of 1.807.952€ and EU Contribution of 990.215 €.

Details of presenting author

Name: Paulo Mourão
Affiliation: University of Évora
Country: Portugal
Short biography: P.A.M. Mourão is a Researcher (permanent position) from University of Évora, Portugal. He has a Physics and Chemistry graduation, a master in Physics, and a PhD in Chemistry, in the Materials and Surface are a. In the last years, he has consolidated his research in the fields of preparation, characterisation, development and application of porous materials, with the focus on the recovery and valorisation of different raw materials and waste, from natural and/or synthetic sources, by its transformation into adsorbents with potential application in the liquid (e.g. dyes, pesticides, pharmaceuticals, metals) and gas phases (e.g. CO2), guided by a circular economy perspective.

Updated status of the project Refineries as Green Hydrogen

L. Romero-Piñeiro, S. Moreno, B. Alonso-Fariñas, A. Ronda, K. Guerra, R. Arjona, M. Campoy, A. Villanueva Perales, D. Fuentes-Cano, S. Nilsson, P. Ollero, J. Pino, E. Romero, P. Haro*

Chemical and Environmental Engineering Department. Escuela Técnica Superior de Ingeniería, Universidad de Sevilla. Camino de los Descubrimientos s/n. 41092 Seville, Spain,
pedrogh@us.es

Abstract: Residual biomass has great potential in Andalusia (Spain) as it is a quite abundant resource. It thus becomes a promising option for the region's energy decarbonisation. This, combined with the existence of two important chemical clusters in Huelva and Algeciras, which demand large amounts of energy and possess technological know-how, makes the area of western Andalusia a strategic enclave for accelerating the implementation of sustainable energy production technologies.

Within this framework, this project has analysed the availability of residual biomass that can be used to produce green hydrogen in the two refineries located in the region. In this way, resources that can be used as feedstock for hydrogen production have been identified according to available quantity, energy density, current use, and seasonality. This was carried out in parallel with the refinery's material balance to establish the current (2022) and projected 2030 hydrogen production process flowsheet diagrams. Based on the study for biomass availability, the greatest potential of suitable waste for hydrogen production comes from the olive oil industry. However, one of the biggest problems associated to this resource is its low energy density. For this reason, the creation of strategic pre-treatment hubs has been proposed, using location-allocation problem, to optimise the transport of the resource. With regard to the refinery's material balance, it has been possible to determine the current state of hydrogen production and future demand. The data have been derived from the refineries' strategy for decarbonisation, as well as from the literature, to adjust the hydrogen production yields of the different units involved.

According to results obtained in the study, the amount of crude oil processed in 2030 would remain unaffected, despite the efforts made to implement renewable technologies at the refinery, such as electrolysis or biomethane reforming. Therefore, the inclusion of hydrogen production technologies using residual biomass from the area could be critical for the decarbonisation of the refinery. Considering the work carried out, even if biomass can not meet all the hydrogen demand forecast for 2030, the coupling of biomass thermochemical technologies using existing refinery facilities (which could be utilised by up to 50%) plus the installation of electrolysers, would be crucial to achieving the European target for 2050.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). The GH2T project (PID2020-114725RA-I00) is funded by MICIU/AEI/ 10.13039/501100011033.

Details of presenting author

Name: Pedro Haro
Affiliation: Chemical and Environmental Engineering Department. Escuela Técnica Superior de Ingeniería, Universidad de Sevilla. Camino de los Descubrimientos s/n. 41092 Seville
Country: Spain

Short biography: Associate Professor Chemical Engineer (Master in Environmental Engineering). PhD in bioenergy systems (thermochemical biorefineries). Fulbright Scholar at Princeton University. Guest researcher at TU Delft, Chalmers University of Technology, NUI-Galway, Karlsruhe Institute of Technology (KIT) Coordinator of Refineries and Petrochemical Industry (Master course). Head of Studies for the School of Engineering. Expert for the European Commission and others for Energy and Sustainability topics. Current research topics: hybridization of solar-biomass systems, scale-up and integration of renewable hydrogen, energy systems analysis, sustainability assessments.

Energy Efficiency and Sustainability of Hydrogen Electric Vehicles: A Promising Path to Sustainable Mobility

Roberta Mota Panizio[1,2*], Ana Carolina Assis[1], Catarina Nobre[1], Paulo Brito[1] and Ronney Boloy[2]

[1]*VALORIZA - Research Center for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, Portugal, * rpanizio@ipportalegre.pt, carolina.assis@ipportalegre.pt, catarina.nobre@ipportalegre.pt, pbrito@ipportalegre.pt.*

[2]*Federal Centre of Technological Education Celso Suckow da Fonseca (CEFET/RJ), Rio de Janeiro, Brazil, ronney.boloy@cefet-rj.br*

Abstract: The automotive industry is one of the main contributors to global emissions, a factor attributed to its high dependence on fossil fuels, which are the main sources of energy [1]. The transition from fossil fuels used in mobility to electricity is one of the main ways to tackle problems related to air pollution and reduce greenhouse gas (GHG) emissions. The transition from mobility to a more sustainable alternative is the result of a series of proposals, the aim of which is to reduce global temperatures by 2°C above pre-industrial levels in accordance with the First Climate Law [2], which stipulates that carbon emissions must be neutral by 2050. Developed countries are seeking strategies for using electric vehicles to replace traditional vehicles that use petrol and diesel, as a way of reducing GHG emissions. However, the use of electric vehicles has problems related to the carbon footprint of battery production, and hybrid vehicles continue to produce exhaust gases when running on hydrocarbon fuels [3]. In a review carried out by Soares et al. 2023, they concluded that the use of cars with batteries needs to be improved with regard to strengthening alternatives for recycling materials, thus making them more attractive to consumers and manufacturers; transparency regarding the value chain, thus improving communication between processes and reducing the risks associated with supply uncertainties; and creating incentive policies as a way to benefit electric vehicle manufacturers, thus making them more economically advantageous [4]. Recently, there has been rapid progress towards the use of low-carbon hydrogen as a substitute in engines for fossil fuels, which is considered a non-polluting fuel, depending on the source. The use of fuel cell vehicles (FCVs) is similar to that of oil-based vehicles, and they can operate continuously as long as they are refuelled, thus overcoming the battery-related problems presented by EVs [5]. Hydrogen technologies are gaining prominence because of their advantages of high efficiency and durability, low noise, zero exhaust emissions (only water), and low refuelling costs [6]. Vehicles equipped with solid oxide fuel cells (SOFC) still present design challenges owing to the high costs involved in powertrain technologies. These challenges are mainly related to the materials used and their durability, which requires more investment in fundamental research to improve them [7]. Hybridization with SOFCs and storage systems with batteries or supercapacitors are alternatives that are being considered [8]. There has been an increase in the number of studies on FCEVs as a way of balancing supply and demand and making prices more favorable compared to other vehicles. When analyzing costs, important parameters such as the fuel cell system used in the vehicle, hydrogen refuelling stations, battery/traction engine, life cycle assessment, and system sustainability must be considered. Greene and Duleep reported that by 2050, vehicles using the fuel cell system will fall to around US$ 22/kW [9]. In addition to the prices involved in producing hydrogen-powered cars,

there is a need to reduce the production price of hydrogen and conduct studies on the financial viability and sustainability of these systems, as detailed by Soares et al. 2022 [10].

References

1. Olabi, A.G.; Wilberforce, T.; Abdelkareem, M.A. Fuel Cell Application in the Automotive Industry and Future Perspective. Energy 2021, 214, 118955, doi:10.1016/j.energy.2020.118955.
2. European Commission European Climate Law; 2021;
3. Mendez, C.; Contestabile, M.; Bicer, Y. Hydrogen Fuel Cell Vehicles as a Sustainable Transportation Solution in Qatar and the Gulf Cooperation Council: A Review. Int. J. Hydrogen Energy 2023, doi:10.1016/j.ijhydene.2023.04.194.
4. Soares, L.O.; Reis, A. da C.; Vieira, P.S.; Hernández-Callejo, L.; Boloy, R.A.M. Electric Vehicle Supply Chain Management: A Bibliometric and Systematic Review. Energies 2023, 16, doi:10.3390/en16041563.
5. Fernández, R.Á.; Pérez-Dávila, O. Fuel Cell Hybrid Vehicles and Their Role in the Decarbonisation of Road Transport. J. Clean. Prod. 2022, 342, doi:10.1016/j.jclepro.2022.130902.
6. Ferreira-Aparicio, P.; Conde, J.J.; Chaparro, A.M. Fundamentals and Components of Portable Hydrogen Fuel-Cell Systems; Elsevier Inc., 2018; ISBN 9780128131282.
7. Ma, S.; Lin, M.; Lin, T.E.; Lan, T.; Liao, X.; Maréchal, F.; Van herle, J.; Yang, Y.; Dong, C.; Wang, L. Fuel Cell-Battery Hybrid Systems for Mobility and off-Grid Applications: A Review. Renew. Sustain. Energy Rev. 2021, 135, doi:10.1016/j.rser.2020.110119.
8. Tanç, B.; Arat, H.T.; Baltacıoğlu, E.; Aydın, K. Overview of the next Quarter Century Vision of Hydrogen Fuel Cell Electric Vehicles. Int. J. Hydrogen Energy 2019, 44, 10120–10128, doi:10.1016/j.ijhydene.2018.10.112.
9. Greene, D.L.; Duleep, G. Status and Prospects of the Global Automotive Fuel Cell Industry and Plans for Deployment of Fuel Cell Vehicles and Hydrogen Refueling Infrastructure; 2013; ISBN 1800553684.
10. Soares, L.O.; de Almeida Guimarães, V.; Boloy, R.A.M. Comparison of Electric Vehicle Types Considering the Emissions and Energy-Ecological Efficiency. Clean Technol. Environ. Policy 2022, 24, 2851–2863, doi:10.1007/s10098-022-02365-3.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Roberta Mota Panizio
Affiliation: *VALORIZA - Research Center for Endogenous Resource Valorization, Polytechnic Institute of Portalegre*
Country: Portugal

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

Concept for a net-zero wheat straw product-driven biorefinery

Sebastian Serna-Loaiza[1], Fabian Schipfer[2], Anton Friedl[2], Bettina Mihalyi-Schneider[3], Walter Wukovits[2] and Michael Harasek[2]

[1] Christian Doppler Laboratory for Next-Generation Wood-Based Biocomposite, Institute of Chemical, Environmental and Bioscience Engineering, TU Wien, Vienna, Austria

[2] Research Unit of Thermal Process Engineering and Simulation, Institute of Chemical, Environmental and Bioscience Engineering, TU Wien, Vienna, Austria

[3] Research Unit of Process Systems Engineering for Bioresources and Sustainability, Institute of Chemical, Environmental and Bioscience Engineering, TU Wien, Vienna, Austria

Abstract: Developing sustainable biorefineries is imperative for transitioning to a sustainable society. The primary objective of these biorefineries is to maximize biomass utilization for materials while utilizing the remaining fractions to power the process. Sections of the pulp fraction post-pretreatment, the hemicellulose sugar fraction, and a portion of the raw material can be harnessed to generate necessary energy, either through coupling with biogas production or via thermochemical conversion of biomass. We aim to investigate the concept of an "energy self-sufficient biorefinery" using wheat straw as a case study, focusing on refining into hemicellulosic sugars, lignin, and cellulose-enriched pulp. The concept's scope lies within primary biorefining, emphasizing intermediate production. This biorefinery concept underwent simulation in Aspen Plus V10.0, with Aspen Energy Analyzer employed to calculate energy requirements. Subsequently, a portion of the feedstock was allocated for direct energy production via combustion. However, the valorization of the cellulose-enriched pulp, whether through biogas or thermochemical means, fell short of meeting the energy demand of such a biorefinery concept. Nonetheless, the biogas stage diversified the product portfolio. Utilizing hemicellulosic hydrolysate enhanced biogas potential, though a combined heat-power system fueled by biogas remained insufficient. Introducing an additional thermochemical energy production step from feedstock effectively met energy demands, allowing calculation of the total biomass required for an energy-self-sufficient biorefinery. This represents an initial stride towards conceptualizing net-zero biorefineries, with further optimization necessary to align techno-economic and environmental aspects and identify optimal configurations.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Lignin-Bonded Composites from Sawmill-Byproducts

Sebastian Serna-Loaiza[1], Cornelia Hofbauer[1], Luisa Scolar[1], Rustam Ibadov[1], Nauman Wahab[1], Gabriel Unsinn[2], Thomas Harter[1], Luis Zelaya[2], Florian Zikeli[3], Josef Füssl[2], Anton Friedl[1], Michael Harasek[1], Markus Lukacevic[2]

[1] Christian Doppler Laboratory for Next-Generation Wood-Based Biocomposite, Institute of Chemical, Environmental and Bioscience Engineering, TU Wien, Vienna, Austria

[2] Christian Doppler Laboratory for Next-Generation Wood-Based Biocomposite, Institute for Mechanics of Materials and Structures, TU Wien, Vienna, Austria

[3] Research Unit of Thermal Process Engineering and Simulation, Institute of Chemical, Environmental and Bioscience Engineering, TU Wien, Vienna, Austria

Abstract: Wood has been used for centuries for structural construction. However, only about 50% of wood trunks are converted into lumber, and the remaining sawmill by-products are used in other value chains like pulp/paper or burned as pellets. As a result of the latter, the outstanding wood fiber structure is destroyed, and carbon is released into the atmosphere. Particleboards are a material-use of these by-products, yet the application is limited to low-strength applications; the resistance depends on the adhesive, which is mostly of synthetic origin and often leads to the emission of contaminants. Therefore, the challenge lies in bringing these separate wood pieces into a composite where the fibers can bond and form new covalent bonds, leading to high-strength properties. All lignocellulosic components –cellulose, hemicellulose, lignin, and extractives– are necessary to reconstruct these separate pieces into a homogeneous high-performant material. Our strategy to tackle this challenge is to disassemble the sawmill by products through a thermo-chemical-mechanical pretreatment, where we control the composition of the native hemicellulose-lignin in the cellulosic fibers. Then, solubilized lignin, hemicellulose, and extractives, which have high reactivity and cross-linking capability, are used as binders. We have tested different chemical pretreatments (e.g., organosolv, liquid hot water, soda, peracetic acid), followed by mechanical treatment (e.g., refining, mixing) to ensure defibration followed by swelling of the fibrous material and impregnation with lignin. Through hot compression molding (150-200°C and 20-45 MPa), we reassembled the materials into composite bars with bending strengths between 40-120 MPa. These values already show immense potential for the produced composites, yet challenges like homogeneity and process conditions are optimization hotspots.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Sebastian Serna-Loaiza
Affiliation: Christian Doppler Laboratory for Next-Generation Wood-Based Biocomposite, Institute of Chemical, Environmental and Bioscience Engineering, TU Wien
Country: Vienna, Austria

Short biography: Full-time postdoc at the Research Unit of Thermal Process Engineering and Simulation at TU Wien. He holds a master's and a bachelor's degree in chemical engineering from Universidad Nacional de Colombia and a PhD in chemical engineering from TU Wien. His main research field is circular bioeconomy and biorefineries. He has expertise in experimental pretreatment of biomass and valorization of lignocellulosic feedstocks aimed to develop biorefinery concepts, process simulation, and techno-economic, environmental, and lifecycle assessment, targeting the production of chemicals, materials, and biocomposites.

Harvesting the natural bounty: N-rich carbonaceous adsorbents from agricultural and marine biomass residues

Valentina Gargiulo[1*], Alessio Occhicone[1], Luciana Cimino[1], Ernesto Mollo[2], Michela Alfe[1]

[1] *CNR – STEMS Institute of Sciences and Technologies for Sustainable Energy and Mobility, Naples, Ital*

[2] *CNR - ICB Institute of Biomolecular Chemistry, Pozzuoli (Naples), Italy*

**valentina.gargiulo@stems.cnr.it*

Abstract: The interest in carbon-rich adsorbents derived from biomass residues for the sequestration of different types of pollutants (greenhouse gases, dyes, heavy metals, crude oil components) has constantly increased. These 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 leads to their adsorption efficiency in 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.

In this work we focus our attention on the production of N-rich carbonaceous materials to investigate the role of nitrogen containing functional groups on pollutants adsorption performances. To this aim, we have selected as raw materials biomass residues characterized by a high N content: thistle (*Cirsium vulgare*), chitosan (obtained from the chitin of crustacean shells), beached *Posidonia oceanica* (commonly known as Neptune grass or Mediterranean tapeweed), *Caulerpa cylindracea* (a green algae widely considered as an invasive species in South Australia and in the Mediterranean Sea where it was unintentionally introduced in the early 1990s), *Asparagopsis taxiformis* (a species of red algae, distributed in both tropical and in warm temperate waters). Chemical procedures to increase the nitrogen content as well as both the surface area and the porosity of the biomass-derived materials were also applied on lignocellulosic biomass residues like rice husk and sawdust. All the materials, obtained carbonizing the biomass residues at 550°C under nitrogen atmosphere, underwent a deep chemico-physical characterization and a selection of them was tested for the adsorption of model pollutants. The relationship between chemico-physical characteristics of N-rich char samples and the pollutant uptakes were evaluated.

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology). This research activity was funded by "ECCSELLENT - Development of ECCSEL R. I. ItaLian facilities: usEr access, services and loNg-Term sustainability" Code: IR0000020 – CUP F53C22000560006, "Programma di Ricerca e Innovazione "NEST -Network 4 Energy Sustainable Transition" CUP B53C22004060006" and by "Accordo Di Programma MiTE – ENEA – CUP B93C22000630006".

Details of presenting author

Name: Valentina Gargiulo
Affiliation: CNR – STEMS, Institute of Sciences and Technologies for Sustainable Energy and Mobility
Country: Italy

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

Struvite crystallization from dairy wastewater after hydrothermal carbonization

Aleksander Opacki, Witold Kwapinski

Chemical Sciences Department, University of Limerick, Limerick, Ireland

witold.kwapinski@ul.ie

Abstract: Many European countries have begun implementing policies aimed at phosphorus recovery from waste. Struvite, a magnesium ammonium phosphate crystal, can serve as a valuable source of these elements for agricultural use. Struvite forms orthorhombic crystals, comprising distorted $Mg(H_2O)_6^{2+}$octahedron, regular PO_4^{3-}octahedron, and groups of NH_4^+ions, all connected by hydrogen bonding. Dairy process sludge can be harmful to the environment and lead to eutrophication. We applied the hydrothermal carbonization (HTC) process as a new technique, allowing for the valorization of slurry into two main products: hydrochar and liquid.

The pH of the solution has been found to be one of the most important physicochemical properties for the crystallization of struvite, influencing both struvite formation and the rate of crystal growth. As shown in Table 1, the largest amount of phosphorus in the liquid was obtained after lowering the pH of the reagents mixture. While iron and aluminum containing flocculants are used for phosphate sedimentation, they are present in the liquid after HTC, and their content only slightly increases after acidification, while the phosphorus content increases significantly. It is important to increase the phosphorus content in the liquid leached from hydrochar, as the precipitation of struvite is performed in the liquid phase. However, due to the high reactivity of Fe clusters, the Fe–P bonding is very stable and formation of struvite will be restricted by Fe content. To increase phosphate content in liquid the Fe–P complexes, the polymerized Fe structure needs to be broken and dissolved. Temperature also influences the process struvite crystals of the highest purity, yield of magnesium ammonium phosphate and the biggest phosphorus removal was obtained in the temperature range from 20 to 25°C.

Table 1. ICP results of HTC liquids from dairy wastewater obtained in different conditions.

		P	Mg	K	Al	Fe	Hg	Cd
170°C	**mg·dm^{-3}**	12.0	20.0	500.0	560.8	482.0	0.0	0.0
180°C		7.0	35.0	550.0	550.9	471.0	0.0	0.0
190°C		8.0	45.0	660.0	570.8	494.0	0.0	0.0
170°C + acid		640.0	182.0	700.0	600.2	550.0	0.0	0.0

Acknowledgments: This publication is based upon work from COST Action WIRE, CA20127, supported by COST (European Cooperation in Science and Technology).

Details of presenting author

Name: Witold Kwapinski
Affiliation: University of Limerick, V94 T9PX Limerick
Country: Ireland

Short biography: Profr. Witold Kwapinski works at the University of Limerick in the School of Chemical Sciences and Chemical Engineering. He completed a PhD in the area of Chemical Engineering. Witold is Course Director of the IChemE-accredited Chemical & Biochemical Engineering (HonsBEng) programme. He is co-leader of the research group on biomass/biowaste thermochemical conversions at UL. He recently received funding to mentor an IRC-funded Post-doctoral Fellow and is currently supervising 3 PhD students as the main supervisor and 3 as a co-supervisor. In the past he successfully supervised 15 PhD students. He is the author of over a hundred publications in ISI journals (h-index = 37 in 2024).

List of presenting authors

Name	Affiliation	Country	Email address
Aldona Balčiūnaitė	Center for Physical Sciences and Technology	Lithuania	aldona.balciunaite@ftmc.lt
Ana Carolina Assis	VALORIZA—Research Centre for Endogenous Resource Valorization	Portugal	carolina.assis@ipportalegre.pt
Ana Momčilović	The Academy of Applied Technical Studies Belgrade	Serbia	amomcilovic@atssb.edu.rs
Atıf Emre Demet	Necmettin Erbakan University	Turkey	aedemet@erbakan.edu.tr
Beni Lew	Ariel University	Israel	benilew@ariel.ac.il
Bogdan-Marian Tofanica	Ion Ionescu de la Brad, Iasi University of Life Sciences	Romania	b.m.tofanica@gmail.com
Bojana Bajić	University of Novi Sad	Serbia	baj@uns.ac.rs
Bruna Rijo	VALORIZA—Research Centre for Endogenous Resource Valorization	Portugal	bruna.rijo@ipportalegre.pt
Charikleia A. Poravou	Centre for Research & Technology Hellas	Greece	cporavou@certh.gr
Corinna Maria Grottola	STEMS-CNR	Italy	corinnamaria.grottola@stems.cnr.it
Elif Ayhan	Hacettepe University	Turkey	eaelifayhan@outlook.com
Eoin Syron	UCD School of Chemical and Bioprocess Engineering Belfield	Ireland	eoin.syron@ucd.ie
Florian Zikeli	University of Tuscia	Italy	zikeli@unitus.it
Francisco M. Cánovas	Universidad de Málaga	Spain	canovas@uma.es

Name	Affiliation	Country	Email address
Georgia Kastrinaki	ARTEMIS Laboratory	Greece	georgiak@certh.gr
Hacı Mehmet Güzey	Sivas University of Science and Technology	Turkey	mehmet.guzey@sivas.edu.tr
Hilal Taymaz-Nikerel	Istanbul Bilgi University	Turkey	hilal.nikerel@bilgi.edu.tr
İlker Özata	Hacettepe University	Turkey	ilkerozata@gmail.com
Karen Trchounian	Yerevan State University	Armenia	k.trchounian@ysu.aml
Klaudia Karkeszová	ENVIEN GROUP	Slovakia	Karkeszova@enviengroup.eu
Liudmyla Nosach	KTH-Royal Institute of Technology	Sweden	nosach@kth.se
Santa Margarida Santos	Polytechnic Institute of Portalegre	Portugal	margarida.santos@ipportalegre.pt
Margit Olle	NPO Veggies Cultivation	Estonia	margit.olle@gmail.com
Maris Klavins	University of Latvia	Latvia	maris.klavins@lu.lv
Marta Goliszek	University in Lublin	Poland	marta.goliszek@mail.umcs.pl
Michela Alfè	STEMS-CNR	Italy	michela.alfe@stems.cnr.it
Mykola Melnychuk	Lutsk national technical university	Ukraine	m.melnychuk@lntu.edu.ua
Nedal Massalha	The Institute of Applied Research, Galilee Society	Israel	nedal@gal-soc.org
Nerijus Striūgas	Laboratory of Combustion Processes, Lithuanian Energy Institute	Lithuania	nerijus.striugas@lei.lt
Nikolaos I. Tsongidis	Centre for Research & Technology Hellas (CERTH)	Greece	ntsongid@certh.gr
Nurinisa Esenbuga	Ataturk University	Turkey	esenbuga@atauni.edu.tr
Olena Sevastyanova	KTH Royal Institute of Technology	Sweden	olena@kth.se

Name	Affiliation	Country	Email address
Omid Hosseinaei	RISE Research Institutes of Sweden	Sweden	omid.hosseinaei@ri.se
Panagiotis Evangelopoulos	RISE Research Institutes of Sweden AB	Sweden	panagiotis.evangelopoulos@ri.se
Paulo Mourão	University of Évora	Portugal	pamm@uevora.pt
Roberta Mota Panizio	VALORIZA—Research Centre for Endogenous Resource Valorization	Portugal	rpanizio@ipportalegre.pt
Sebastian Serna-Loaiza	Christian Doppler Laboratory for Next-Generation Wood-Based Biocomposite	Austria	sebastian.serna@tuwien.ac.at
Valentina Gargiulo	STEMS	Italy	valentina.gargiulo@stems.cnr.it
Witold Kwapinski	University of Limerick	Ireland	witold.kwapinski@ul.ie