WIRE

Waste biorefinery technologies for accelerating sustainable energy processes

Book of abstracts

WIRE's 3rd Working Groups Workshop

Center for Research & Technology Hellas (CERTH)

Thessaloniki – Greece

29-30th March 2023

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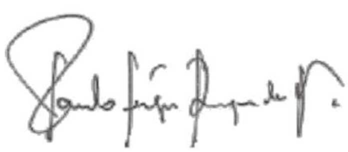
Message from the Action Chair

It is increasingly clear that humanity is confronting two major environmental problems that demand scientific and innovative solutions: the rise in the average temperature of the planet and an increasing production of waste by society. The first problem has resulted from increased carbon dioxide emissions in the last 200 years due to the massive use of fossil fuels. Therefore, it is imperative to develop new sources and ways for energy and fuel production that can be sustainable and simultaneously carbon neutral. The second problem is the increasing production of residues and effluents resulting from a growing human population and how consumer goods are commercialized.

The production of energy and materials from biomass and waste materials is especially favored over fossil-based feedstocks since it has almost neutral net carbon dioxide (CO_2) emissions. Indeed, a biorefinery approach to waste valorization is a sustainable, innovative, and forward-thinking concept that can help the ambitious European goals for carbon neutrality in 2050. To achieve these goals, an effective paradigm shift is required, stopping using non-renewable resources (e.g., oil, natural gas) to produce fuels and materials and starting to use renewable resources, thus minimizing environmental impacts. These include developing biorefineries to transform biomass and organic waste into valuable materials, fuels, and energy.

The WIRE COST Action, and this workshop in particular, is a real contribution to the current effort of promoting ways of transferring knowledge by strengthening academic and industrial cooperation, which together can develop innovative and sustainable solutions for the environment, economy, and society.

This is the way to go!



Paulo Brito, Action Chair

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Introduction

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

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

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

WIRE's MC Meeting & 3rd Working Groups Workshop was held in Thessaloniki (Greece) at the Center for Research & Technology Hellas (CERTH) from 29 to 30 March 2023.

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

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

WIRE's MC Meeting & 3rd Working Groups Workshop had 43 papers presented, divided among the different WGs.

Management of waste streams originated from anaerobic codigestion of food industry sludge with microalgae by biomass recovery

İlker Akmirza, **Merve Evkaya, Pelin Sungur**

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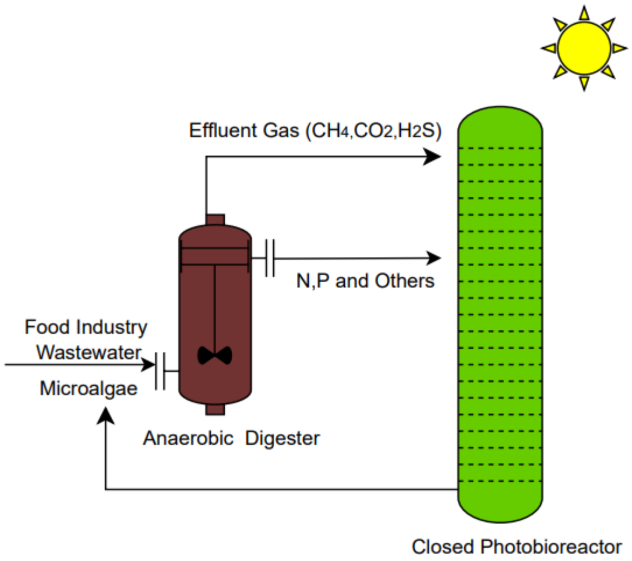
Abstract:

The study is aimed to comply with the WEF (Water- Energy- Food) Nexus goals by establishing a multi stage bioreactor system that provides soil conditioning end product by applying a sludge stabilization process of anaerobic digestion, individually and co-digested with microalgae, which end products will be also used for the enrichment of biogas in the second stage closed photo-bioreactor system. For the improvement of producing a soil-conditioning end product, the effects of co-digestion of food industry sludge together with the microalgae will be examined and proper co-digestion ratio and operation conditions will be determined. As a second goal of the study, the waste streams of the anaerobic co-digestion will be used in microalgal systems as carbon and nutrient source.

Nutrient-rich digestate of anaerobic digestion will be treated via using microalgae and strategies for proper biogas enrichment will be investigated. Obtained microalgal biomass in the photobioreactor will be recycled to anaerobic digestion tank and will be used to target to improve the quality of optimization.



Schematic view of experimental setup

Details of presenting author

Name: **İlker Akmirza**
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Short biography: Ilker Akmirza (İzmit, Türkiye, 1986) graduated in 2009 from Yildiz Technical University, Türkiye as Environmental Engineer. He did his Master at the Environmental Engineering Department of Istanbul Technical University, Türkiye, where he worked for 7 years as teaching and research assistant. He got his Joint PhD Degree from Valladolid University, Chemical Engineering Department and Istanbul Technical University Department in 2019. He is working since 2019 at Gebze Technical University as Assistant Professor and focuses mainly on biogas upgrading systems, valuable product production and odor pollution control.

Valorization of carbon materials from gasification processes in liquid phase adsorption of probe molecules

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

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Abstract:

It is intended to evaluate the possibility of valorization of the by-products, resulting from the gasification of polymeric and natural residues, through their application in liquid phase adsorption processes. The selected residues and the carbon by-products resulting from their thermochemical conversion, after their physical and chemical characterization, will be the target of chemical activation processes. The by-products and the resulting activated materials will be tested in aqueous liquid phase adsorption processes of probe molecules. Regarding the samples, after being chemically activated, the ones that show the best results are those that do not have the incorporation of polymeric material in their composition.

Details of presenting author

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

Modelling of bioethanol production from organic fraction of municipal solid waste

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Abstract:

Municipal solid waste represents one of the most significant environmental problems due to its ever-increasing amounts and large negative environmental impact. Conversion of waste to energy is an integral part of sustainable waste management. Biodegradable waste, waste from gardens and parks, kitchen waste from households, restaurants, and similar waste from food production, as well as an organic fraction of municipal solid waste, can be used to obtain high-value products and energy, reducing environmental pollution and the total amount of waste. Therefore, the development of the biofuel production processes is significant. Bioethanol produced by fermentation represents a modern form of energy and a fossil fuel replacement. Conventional production is based on corn, grain, and sugar-based raw materials. Considering that this represents a problem from the aspect of competition with food sources, bioethanol production has been developed from by-products of various industries or waste lignocellulosic or starch-containing raw materials, such as an organic fraction of municipal solid waste. The development of each bioprocess significantly relies on bioprocess optimization, modelling, and simulation. This research uses the SuperPro Designer bioprocess simulator to generate a simulation model of the bioprocess of bioethanol production from an organic fraction of municipal solid waste. SuperPro Designer has applications in modelling, cost analysis, process bottleneck removal, and environmental impact assessment in biotechnological, food, pharmaceutical, and chemical processes. The developed model predicts process and economic parameters for the analysed biotechnological process of bioethanol production, indicating the sustainability of the proposed model. Results from this baseline model can also serve as the basis for further bioprocess development and enhancement.

Details of presenting author

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

Supported iron-based nano-materials for the valorization of carbon dioxide

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[2]Department of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract:

Carbon dioxide emissions are linked with important environmental concerns and severe greenhouse effects. Recent studies focus on the valorization of carbon dioxide and its effective conversion into high added-value products. Iron-based nanoparticles are promising catalysts for the selective production of olefins or fuels, as they effectively catalyze Reverse Water Gas Shift (RWGS) and Fischer-Tropsch (FT) reactions. In fact, it has been shown that magnetite satisfactorily activates CO_2, promoting its conversion into deoxygenated products; typically, iron catalysts require the use of alkaline additives to achieve the preferred activity and enhance selective distribution towards desired products [1]. This work focuses on the development of iron-based nanoparticles doped with alkali metals, supported on zeolite. Within this context, magnetite nanoparticles, doped with Na and K have been synthesized through co-precipitation method, using a mixture of $FeCl_2 \cdot 4H_2O$ and $FeCl_3 \cdot 6H_2O$ as precursor. Sodium (Na) and Potassium (K) have been added to the precursor's solution at a ratio of 1:1 or 1:2. The produced catalytic materials have been dispersed on zeolite HZSM-5 (80 SAR) in order to effectively catalyse the tandem reaction.
All synthesized samples have been characterized with respect to their morphological and catalytic properties employing various physicochemical methods (e.g. XRD, FT-IR, BET, SEM, Raman, TPD-NH_3). XRD diffractograms confirm the crystalline structure of the magnetite nanoparticles, while the identified phases are magnetite (Fe_3O_4) and hydrous iron oxide ($Fe_2O_3 \cdot H_2O$/β $Fe_2O_3 \cdot H_2O$). A small shift of the $NaFe_3O_4$ and KFe_3O_4 nanoparticles peaks is observed on the corresponding diffractograms, confirming the presence of K and Na ions in their crystal lattice. TPD NH_3 analysis has been employed in order to determine catalyst acidity; $NaFe_3O_4$ presented weak acid sites and low concentration of desorbed ammonia (0.385 mmol/g_{cat}). The zeolite that has been used as support presented weak and relatively strong acidic sites, while the desorbed ammonia was 0.718 mmol/g_{cat}. The presence of both weak and medium acid sites was identified on the supported magnetite nanoparticles (i.e. Fe_3O_4/HZSM-5, $NaFe_3O_4$/HZSM-5, KFe_3O_4/HZSM-5), thereby indicating that the observed acidity is mainly attributed to HZSM-5. Preliminary experiments took place, in a continuous flow reactor (30 MPa, 320 ºC, H_2/CO_2 (3:1)) with online GC monitoring of the produced gas phase, in order to evaluate the performance of the synthesized catalysts. They showed potential for the production of C_1-C_3 deoxygenated products, such as methane, ethylene, ethane, propylene, and propane, among others, upon reduction under pure hydrogen flow prior to exposure of the catalyst to the reaction mixture. Preliminary experiments with different substrates are currently in progress in order to ultimately correlate the catalytic performance with the physicochemical properties attained as a result of the synthesis procedure.

[1] Wei, J., Ge, Q., Yao, R., Wen, Z., Fang, C., Guo, L., Xu, H., Sun, J., Nat. Commun. 8 (2017), 15174.

Acknowledgements
We acknowledge the support of this work by the project "PROMETHEUS: A Research Infrastructure for the Integrated Energy Chain" (MIS 5002704) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

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Name: **Bakratsa Alexandra**
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Short biography: Bakratsa Alexandra (MEng ChE) recently graduated from the Chemical Engineering Department of the Aristotle University of Thessaloniki (July 2022) and since then has been working at the newly established ARTEMIS Laboratory (ARTEMIS stands for LAboratory of novel mateRials & Technologies for sustainable Energy & environMental Integrated applicationS) of the Chemical Process and Energy Resources Institute (CPERI) of CERTH, Greece. Her main work focuses on catalytic reaction engineering, material synthesis and characterization.

N-doped graphene from PET bottles waste as an effective carbon support for PdNi NPs for borohydride oxidation electrocatalysis

Aldona Balčiūnaitė[1], Biljana Šljukić[2], Noha A. Elessawy[3], Marwa H. Gouda[3], Diogo M.F. Santos[2]

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Abstract:

Fuel cells (FCs) as sustainable power sources have attracted more and more attention from researchers. FCs are intrinsically efficient, non-polluting, silent, and reliable. Alkaline fuel cells (AFCs) are advantageous in several aspects as they enable the use of low-cost non-noble metals as electrocatalysts. Additionally, the problems related to hydrogen transportation and storage can be overcome by using liquid fuels.
The work aims to design efficient and inexpensive nanostructured catalysts for borohydride oxidation. The nitrogen-doped graphene (NG) prepared by the thermal decomposition of PET bottle waste with urea was assessed as catalyst support. The different palladium-nickel (PdNi) catalysts were prepared by anchoring Ni nanoparticles on NG (Ni@NG) followed by doping with different (5, 10, 15 wt.%) amounts of Pd (noted as PdNi_5@NG, PdNi_10@NG, PdNi_15@NG). Detailed physicochemical analysis of the newly prepared catalysts was investigated via ICP-OES, XRD, XPS, SEM-EDS, TEM, N_2-sorption analysis, FTIR, and Raman spectroscopy. The electrocatalytic activity of the prepared catalysts was evaluated towards the oxidation of borohydride by cyclic voltammetry in 0.03 M $NaBH_4$ solution in alkaline media (2 M NaOH) in the potential range from -1.2 V to 0.1 V (vs. SCE) using an electrode potential scan rate of 10 mVs^{-1}. The studies showed that the prepared PdNi@NG catalysts have good electrochemical stability in an alkaline $NaBH_4$ solution. The PdNi_15@NG catalyst exhibited the best electrocatalytic activity for the borohydride oxidation reaction. The prepared PdNi@NG catalysts seem to be promising anodic materials for direct borohydride fuel cells.

Details of presenting author

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

PigWasteBiorefinery – A mobile approach for animal waste biorefining

Paulo Brito, **Catarina Nobre, Bruna Petry**

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Abstract:

Waste management in pig farms, one of the most traditional agroindustries in Portugal and Europe, is a serious environmental problem. These industries produce large quantities of effluents with high organic and inorganic loads, with some compounds being highly refractory. Traditionally, the treatment of these effluents consists of biological methods, like composting, anaerobic digestion (AD) or lagooning. However, biological techniques do not represent a complete solution for the treatment of these effluents due to the existence of significant efficiency losses and low biodegradability, with the treated effluent not achieving the required purification levels.

Project PigWasteBiorefinery consists of a mobile demonstrator unit that uses pig farm effluents as feedstock. The unit is based on the combination of AD and electrooxidation to produce biogas and hydrogen, respectively. After production, the gases are converted into thermal energy and electricity in a solid oxide fuel cell (SOFC) at a minimum temperature of 500°C. The sludge digestate from AD is further used in a gasification process to yield syngas. This approach intends to overcome the limitations of exclusively using biological methods for wastewater remediation through an integrated and circular approach that deals with the contaminated effluents, as well as the by-products from the treatments.

After on-site collection, the effluent enters the system through a mechanical pre-treatment zone where non-organic solids are removed, before being pumped to the AD reactor. The digestion process occurs in continuous mode in a single-stage reactor under mesophilic conditions (35 °C). The produced biogas is removed from the system, cleaned, and forwarded to the SOFC. The liquid effluent exiting the digester is fed into a settling tank and pumped to the electrooxidation reactor for post-treatment of the non-biologically degradable fraction and hydrogen production. On the other hand, the solid digestate leaving the reactor is controlled by a worm screw. This screw moves the generated solids through a drying system, with the possibility of excess water re-entering the system and the sludge advancing to a gasifier for syngas production. Both the hydrogen and the syngas are used to enrich the gas mixture that will feed the SOFC.

Overall, the development of a biorefinery concept for pig farms based on effluents generated on-farm is an important contribution to effective natural resource management. The results from this project are intended to contribute to the development and demonstration of an integrated process chain that relieves the impact of pig farms on the environment.

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Short biography: Paulo Brito has a degree in Chemical Engineering (IST, Portugal), a MSc in Corrosion Science and Engineering (UMIST, UK), an MBA (INDEGISCTE) and a PhD in Chemical Engineering focused on Electrochemistry (IST, Portugal). He is a Coordinating Professor with Tenure and Aggregation at IPPortalegre's Technology and Management School (ESTG), and coordinates VALORIZA (Research Center for Endogenous Resource Valorization). His main research interests are related with bioenergy, waste management and thermochemical valorization, materials' corrosion, galvanic energy production, and production of renewable gases (hydrogen and methane) from thermochemical processes. He has published more than 200 works in papers, books, and proceedings (http://orcid.org/0000-0002-2581-4460).

Valorization of xylan

Ali Oguz Buyukkileci, Senem Yanak, Nuket Zeybek, Nuran Temelli, Ece Sürek

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Abstract:

Xylan is one of the most abundant natural polysaccharides, composed of β-1,4 linked xylose backbone and several substitutions.

Xylose cannot be utilized efficiently by many industrial microorganisms and xylan acts as a barrier against cellulolytic enzymes, along with lignin. Therefore, xylan and xylose are overlooked in many bioprocesses and discarded after pretreatments before cellulose hydrolysis in biotechnological manufacturing of fuels or other products. On the other hand, xylan and its hydrolysis products, xylose and xylooligosaccharides (XOS), find several (potential) uses in the industry. Xylose is the feedstock for microbial and chemical xylitol synthesis. Furfural is obtained by the dehydration of xylose. XOS show prebiotic activity, proliferating beneficial bacteria in the human and animal large intestine. In its polymeric form, xylan can be used to prepare biocomposites for packaging materials and hydrogels. There are attempts to use xylose as a carbon source for ethanol, lactic acid, succinic acid and other fermentation products.

At IZTECH, we are developing technologies for the efficient valorization of lignocellulosic applying a xylan-first biorefinery approach. The conditions of the pretreatment steps are fine-tuned according to the target bioproduct. In liquid hot water treatment, extraction of xylan and its simultaneous hydrolysis into XOS is maximized. Organosolv and deep eutectic solvent treatments were optimized to keep the xylan in the solid biomass, while decreasing the recalcitrance against the enzymatic attack. Proper selection and application of enzymes yields either XOS or xylose and glucose in the subsequent enzymatic hydrolysis steps. We test the prebiotic activity of the XOS and xylan using selected colon bacteria. The other application under study is nanoparticle formation using xylan to design microbially activated drug carriers. The pretreatments and xylan extraction allow easier hydrolysis of cellulose remaining in the solid streams.

Details of presenting author

Name: **Ali Oguz Buyukkileci**
Affiliation: İzmir Institute of Technology (IZTECH)
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Short biography (should not exceed 100 words): I am a faculty member in the Department of Food Engineering and the head of the Department of Biotechnology and Bioengineering (interdisciplinary) at IZTECH. I was trained as a food engineer at the Middle East Technical University, Türkiye, and got a Ph.D. degree in biotechnology from the same university. My research activities are in industrial biotechnology, such as the application of microorganisms and enzymes for the manufacture of bioproducts. Currently, my lab group carries out projects focusing on the valorization of lignocellulosic, with a particular interest in the xylan fraction.

Quantifying the environmental impact of cottonseed oil-based biodiesel production in Türkiye through Life Cycle Assessment

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Abstract:

Biodiesel technology provides a sustainable instrument for producing environmentally benign, non-poisonous, and biodegradable transportation fuel. The production of biodiesel can be obtained from various feedstocks of vegetable oils and animal fats. Among these vegetable oils, cottonseed oil is employed in the biodiesel process due its composition of different triglycerides through the transesterification reaction. In the meanwhile, Türkiye is well-known for cotton production commercially resulting having high potential in producing cottonseed oil. Life cycle assessment (LCA) is one of the comprehensive measures that used to analyze the environmental sustainability of biodiesel production as well as to detect the invisible positive and negative impact of the process. The main purpose of this study is to determine the potentials of environmental impact categories associated with the process of producing biodiesel from cottonseed oil in Türkiye, the categories basically include global warming, acidification, abiotic depletion, and eutrophication potentials. The work has been carried out in the OpenLCA software using the impact assessment method CML-IA baseline to quantify the mentioned categories. The LCA has been performed in processes of cotton agriculture, cotton ginning, cottonseed oil extraction, oil refinement, and transesterification. The study adopted a functional unit of 1 ha of cotton field that can be able to produce approximately 577 kg of biodiesel in Türkiye. The results have shown that the most affected category is the global warming potential, it has total amount of 60.541 kg CO_2-eq. In addition, the stages of cotton ginning, oil extraction, and oil refinement demonstrated high levels of impact categories while the transesterification stage showed the lowest impact.

Details of presenting author

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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.

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

Ioannis A. Fotidis[1,2]

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Abstract:

Anaerobic digestion (AD) process instability with suboptimal methane production usually occurs due to excess ammonia from the substrate degradation. Bioaugmentation with ammonia-tolerant methanogens into inhibited AD systems was proposed as a successful in-situ remediation strategy to alleviate ammonia toxicity. Recent researches proved biochar harbour potential to stimulate direct interspecies electron transfer between syntrophic acetogenic and methanogenic communities. The combined effect of the bioaugmentation with ready-to-use inocula and biochar addition in continuous reactors were assessed in an earlier study. In full-scale biogas production, AD reactors may suffer from other ammonia shocks, but the long-term stability of bioaugmented AD systems, without performing another bioaugmentation, and their ability to alleviate further ammonia toxicity has never reported.
The current study aims to evaluate the long-term performance of a biochar enhanced novel bioaugmentation strategy in CSTR reactors at high ammonia levels and the role of the microbiome on the potential AD process recovery or stability.
Therefore, two CSTR reactors (R_1 and R_2), were operated under thermophilic conditions (55°C) with hydraulic retention time of 15 days. The working volume of the reactors was 1.8 L. The reactors were fed with food waste (i.e., pre-treated into organic fraction by pulping, volatile solids (VS) of 45.34 ± 0.22 g L^{-1}, total ammonium nitrogen of 0.84 ± 0.02 g NH_4^+-N L^{-1}, pH of 4.31 ± 0.04 and biochemical methane potential (BMP) of 474.5 ± 18.7 mL CH_4 g^{-1} VS). The two reactors had been running for 90 days and had experienced an identical ammonia shock from 0.84 to 4.5 g NH_4^+-N L^{-1} before the new strategy was applied. Gel-immobilized inoculum and biochar were bioaugmented into R_2, while R_1 was the control reactor.
Bioaugmented and control reactors suffered 31.3% and 17.1% production loss, and subsequently achieved 100% methane production recovery and 13%, respectively at 5.5 g NH_4^+-N L^{-1}. The bioaugmented reactor acclimatized to 6.5 g NH_4^+-N L^{-1} with 71.7% original methane yield compared to 36.9% in control reactor. Overall, biochar addition promoted the stability of microbial community, protected the introduced *Methanoculleus* sp. and syntrophic VFA-oxidizing bacteria and overall enhanced bioaugmentation with long-term ammonia tolerance to ammonia toxicity events. This novel bioaugmentation strategy can efficiently alleviate repetitive ammonia shocks and its results are expected to last for many HRTs.

Acknowledgements
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Second generation biomass gasification: The Syngas Platform Vienna - current status

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Abstract:

Product gas from gasification has been identified as a key technology for the development of sustainable biorefineries. Steam gasification in a dual fluidized bed reactor has already been developed in the power sector from lab- to commercial-scale for woody biomass as feedstock. A trend towards utilizing feedstock of lower quality, such as low-grade biomass, biogenic residues or waste drives the development of the technology in terms of reactor design, gas cleaning and optimizing operation parameters. At the same time the need for production of sustainable end products more valuable than electricity and heat leads to the embedding of dual fluidized bed gasification into complete process chains.

In Vienna, Austria, such a comprehensive biorefinery for the conversion of biogenic residues and waste has been commissioned and operated with waste as input material. An advanced reactor design for dual fluidized bed gasification has been implemented at a capacity of 1 MW thermal fuel input for long-term operation (>10 days continuous operation). The reactor design was based on a 100 kW pilot plant at TU Wien, where experimental investigations have shown increased fuel conversion, reduced tar amounts in the product gas, and subsequently an overall better performance, especially for converting biogenic residues and waste.

The 1 MW gasification plant is part of the Syngas Platform Vienna, which consists of a full process chain combining waste gasification with a downstream Fischer-Tropsch-synthesis pilot plant. In addition, a slip stream of the product gas can be used in a connected laboratory for research in the fields of advanced gas cleaning, biological gas upgrading, and hydrogen upgrading and separation.

While product gas from renewable sources is considered to be one of the key technologies in a more sustainable energy and material cycle system, to date it has not been adopted widely by industry. While numerous desirable feedstocks, such as low-grade biomass, biogenic residues or waste have been shown to be suitable in small-scale experiments and equally numerous synthetic pathways for the product gas exist, this has not yet been demonstrated in an integrated process chain. Thus, we aim to demonstrate such an integrated process chain from biogenic residues and waste to a valuable end product using our Syngas Platform Vienna.

Figure **1** shows the overall concept of the platform indicating the shifting research focus towards low-grade feedstock and high-valuable end products.

Industrial adoption of syngas technology has been hampered by the challenging economic

situation of increasing feedstock costs (for e.g. wood) and decreasing product prices (e.g. reduction of feed-in tariffs for green electricity). In order to make the technology both economically viable and equally environmentally more impactful, it is therefore necessary to improve both sides: the spectrum of possible feedstock as well as the product range that can be produced from them.

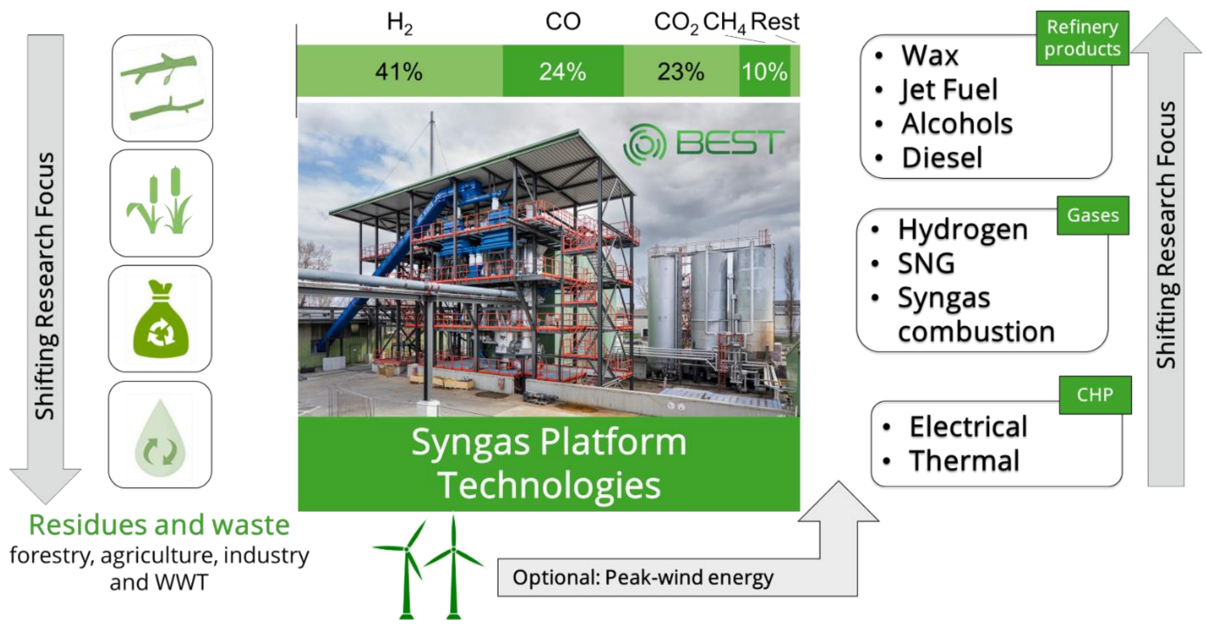

Figure 1: Shifting Research Focus of the Syngas Platform Vienna.

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Short biography**:** Katharina Fürsatz is working as Senior Research at BEST – Bioenergy and Sustainable Technologies GmbH in the field of fluidized bed gasification of residual fuels and is the Austrian representative in the WIRE Management Committee. She obtained her PhD from TU Wien in 2021 studying the influence of fuel ash on gasification performance in dual fluidized bed steam gasifiers for which she obtained a Lions Sponsorship for scientific exchange. Currently, she is also working as a Guest Researcher at Umeå University to study the production of ammonia during gasification and its utilization potential, funded as a Kempe Foundation Stipend.

Acid-catalyzed liquefaction of biomass as a central process for sustainable and renewable products

Rui Galhano dos Santos, João Bordado, Ana Cristino, Ivo Paulo, Sila Oskan, Suzete Almeida, Teresa Arlete, Diogo Gonçalves, Tânia Costa, Olga Ferreira, Raquel Gonçalves

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Abstract:

The industrial and technological advances achieved over the years regarding societal well-being and economic stability are firmly grounded on affordable energy and commodities that are still, to date, highly dependent on fossil sources. New approaches involving greener processes are of utmost importance to assure the survival of future generations. Concepts such as biorefineries, circular economy, cradle-to-cradle, and neutral emission cycles play a pivotal role in the transition to a greener and more sustainable future. Biomass is envisaged as having a crucial role in achieving the desired carbon neutrality, as it can be used as a raw material for sustainable chemicals and energy carriers. Biomass upgrading is the process of transforming biomass, such as agricultural residues, forestry waste, and municipal solid waste, into high-value products that can be used for energy, fuels, chemicals, and materials. This process involves converting the raw biomass into a more refined and valuable form, such as biofuels or bioplastics, through various physical, chemical, and biological methods.

In this scenario, underpinned by a transition to renewable energy sources and materials and by the efficiency of resource use, the development of a platform to produce energy carriers and chemicals by upgrading wastes and biomass is under development. The central and critical driving force of such a platform is Thermochemical Liquefaction. Acid-catalyzed biomass liquefaction is a chemical process that involves the conversion of biomass into a liquid form using an acid catalyst. The process typically involves heating the biomass in the presence of a strong acid. The acid catalyst breaks down the complex biomass molecules into smaller fragments, which can then be converted into liquid products. This process has been applied to several residues allowing the production of polyols, foams, sugars, fuels, adhesives, and antioxidants.

Our ongoing research is focused on optimizing the production and use of bio-oils from biomass liquefaction. This includes developing new technologies for refining and processing bio-oils. The work developed so far regarding biomass upgrading via liquefaction will be presented.

Details of presenting author

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

NOMAD mobile bio-fertiliser solutions unlocking the value of digestate

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Abstract:

The reuse of waste in order to create raw materials in a sustainable and efficient way is a new development strategy for the transition to a circular economy. Biogas plants transform organic waste that otherwise would end up in landfill, into biogas using anaerobic digestion. Such plants, also produce digestate as a by-product, a rich source of nutrients and its application in soil is suitable for enrichment with inorganic and organic components. This constitutes an alternative, environmentally-friendly approach for the replacement of chemical fertilizers, the production of which is associated with high GHG emissions and a continuous reduction of mineral resources.
However, the digestate has variable chemical composition based on the variations in the raw materials that are used as feed in the anaerobic digesters. This creates issues in the utilization of the digestate and consequently a major management issue for storage or disposal of large amounts of materials, that may pose a serious threat to the environment. Direct disposal in the soil results in an uncontrolled leaching of nutrients that are transported to the surface and groundwater causing pollution. Depending on its origin, digestate may contain high risk contaminants, such as pharmaceuticals, in cases of livestock or municipal waste treatment sludge.
Currently, separating digestate into liquid and solid fractions is the most common tactic for easier management, reducing volume and therefore transport costs. The methods used are screw separation, centrifugation and filter press, achieving the separation of the digestate, however they are extremely energy consuming and increase power consumption. Ammonia stripping for nitrogen recovery and membrane separation have been proposed for the liquid fraction treatment. Furthermore, advanced technologies such as membrane distillation and microbial cell recovery have been studied, but have not been applied on a large scale yet.
The present work focuses on the design of a technology for the processing of digestate in a more compact way with the target to reduce the overall volume of the digestate by 85-90%, to recover nutrients from the liquid fraction of the digestate and to remove antibiotics for the production of clean water. Digestate solid-liquid separation, filtration and alternative methods for the recovery of nutrients (selective electrodialysis) and the removal of antibiotics (advanced oxidation) are integrated into a system that uses as a feed digestates from different origins (agricultural, animal residues, food waste, municipal waste) that are produced from anaerobic digestion plants. The digestate-derived fertilizers and soil amenders are tailored to farmers' soil and crop requirements

aiming to replace non-renewable mineral fertilizers and to produce clean water for the process needs as well as for irrigation purposes. The technology addresses key digestate management issues including environmental and health risks, handling, variable composition and the increasing volume being produced. Currently, turning digestate into fertiliser products is not feasible for most small biogas plants that cannot afford investing in expensive and energy consuming installations for the processing of a "waste" by-product.

Acknowledgements
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Short biography: Dr. Ioannis Garagounis is a post-doctoral researcher at the Chemical Process and Energy Resources Institute. He obtained his PhD from the Department of Chemical Engineering of the Aristotle University of Thessaloniki in 2016. His research interests have focused on green electrochemical processes, including CO2 utilization, electrochemical ammonia synthesis and biomass to energy conversion technologies. He has co-authored 24 articles in international peer-reviewed journals, 25 papers in international conference proceedings and 15 in national conference proceedings, accruing over 1100 citations and an h-index of 15 (Scopus). Currently, his research focuses on nutrient recovery and digestate valorization.

BIOFLEXPOR Technology towards 2G bioethanol biorefineries

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Abstract:

By 2030, decarbonizing the transport sector will become mandatory requiring the introduction of advanced biofuels into the market, with minimum targets of 1% in 2025 and 3.5% in 2030 in accordance with the RED II Directive. To avoid future biofuels imports, it is essential that an industrial cluster emerges in Portugal with the capacity to produce advanced biofuels, such as 2G Bioethanol.
In this context, the team from Bioenergy and Biorefineries Unit (UBB) of LNEG (*Laboratório Nacional de Energia e Geologia*) has been actively working on the development of an innovative and fully integrated technological strategy to produce advanced bioethanol using agricultural and forestry residual biomass as sustainable feedstock. The target is the demonstration, at relevant environment, all stages of the production technology, enabling the direct obtention of a biofuel that complies with EN standards, allowing its immediate blending with other fuels, such as gasoline. The prototype is based on a proprietary non-catalyzed steam explosion technology, i.e., without the addition of acids and using only high-pressure steam, called FLEXBIO™, initially developed by the company Stex and since 2019 in partnership with LNEG. The LNEG team has also been conducting R&D aiming at the development of new yeasts and enzymes that enhance the conversion of both cellulosic and hemicellulosic fractions of biomass. All technology will be environmentally sustainable, in terms of GHG emissions and waste production, promoting the circular bioeconomy.
This innovative technology for a 2G bioethanol biorefinery, enabling to obtain a biofuel with high energy quality and sustainable origin from different types of biomasses, has been demonstrated in a relevant environment (TRL 5) in a prototype simulating (at scale 1:15) the commercial installation, under the BIOFLEXPOR project. The consortium is led by the company Prio Bio, S.A., the largest producer of biofuels in Portugal, and includes, in addition to LNEG, I.P., teams from CBE (Centro de Biomassa para a Energia) and Florecha – Forest Solutions, S.A. (*Forest Solutions*).
The technology - under optimization but already demonstrated for the conversion of corn stover, olive tree pruning and eucalyptus-based forest residual biomass, yielding close to 150 L Ethanol /ton biomass (oven-dried weight) - will respond to a lack of economically viable technical solutions for small-scale biorefineries that process 200-700 tons/day of biomass, corresponding to a nominal bioethanol production capacity of 10,000-30,000 ton/year. It may therefore be close to a commercial application, which will be of strategic importance for the BIOFLEXPOR consortium, and for the LNEG team.

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Olive bagasse and pig farming effluents as feedstocks for biorefinery concepts

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Abstract:

Agroindustries are a source of materials, wastes and effluents that may be treated, converted and valorized according to a biorefinery strategy. The conjugation of different processes helps to improve the recovery of materials and energy and to diversify the range of marketable products. In this work we present two models of biorefinery concepts that are being studied at Portugal involving cooperation between NOVA University, Polytechnic Institute of Portalegre and BIOREF – Laboratório Colaborativo para as Biorrefinarias.

Olive bagasse biorefinery – Wet olive bagasse has been treated by filtration and drying to increase total solid contents and the solid fraction was milled and fractionated to obtain a fraction rich in olive stones with good characteristics for energy valorization. Olive pulp-rich fractions were evaluated as a source of residual oil, polyphenols, animal feed or precursors for biochars. Both wet olive bagasse and olive mill wastewater were subject to hydrothermal treatment to produce hydrochars and an aqueous phase that can be used in anaerobic digestion or electrolytic hydrogen production. Biochars and hydrochars can be used as soil additives, adsorbents, or biofuels.

Pig farming effluent biorefinery – Sludges from a pig production unit were treated by filtration through a biomass filter to reduce suspended solid contents and the filtered liquid was used for biogas production through anaerobic codigestion with A. donax biomass. The digestate can be filtered through powdered biomass and the clarified liquid used for C. vulgaris production. The microalgae culture may be used as a scrubber for biogas upgrading, capturing CO_2, and increasing CH_4 concentration. The effluent from the microalgae reactors can be further treated by photo-oxidation and subsequently used for hydrogen production through electrolysis. The spent biomass filters can be used for composting or further production of biomethane through anaerobic co-digestion.

These integrated solutions of biorefineries to treat and valorise complex wastes are needed as an option to reduce costs of waste management operations. The combination of thermochemical, biochemical, and electrochemical technologies allows the diversification of end products and the recycling of nutrients and carbon materials avoiding less sustainable options.

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Commissioning of a lab-scale CO_2-Fischer-Tropsch plant for three-phase kinetic studies

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Abstract:

The Fischer-Tropsch synthesis (FTS) has been used on technical scales as X-to-Liquid technology since the 1920s. Here, CO and H_2 react on a heterogeneous catalyst, commercially Fe or Co-based, in an exothermic polymerization reaction to form linear hydrocarbons over a broad range of chain lengths. Applying an Fe-based catalyst, the FTS can be performed with CO_2 as feedstock instead of CO, making it appealing for Power-to-Liquid processes. As Fe catalyzes both, the reverse Water-Gas Shift (rWGS) reaction in addition to FTS, a separate upstream rWGS unit usually operating at high temperatures can be omitted. Most research thus far focused on catalyst development and kinetic studies on sub-gram scales. Moreover, the inhibitory effect and deactivation caused by H_2O has been discussed but never accessed in detail as H_2O concentration is usually calculated via oxygen balance instead of being measured directly. To cope with the occurring load changes in renewable H_2 and CO_2 supply as well as the exothermic reaction, a three-phase reactor concept, e.g. the for traditional FTS used slurry bubble column reactor (SBCR) seems most promising. For industrial applications in-situ reduction of the catalyst, especially without the use of CO can immensely reduce operating costs.
In order to investigate the three-phase CO_2-FTS, we designed and constructed a lab-scale plant consisting of a fixed bed and stirred tank reactor for catalyst loadings of 1-20 g with syngas throughputs up to 300 ml/min. The plant is equipped with an in-line spectroscopic H_2O-measurement of the hot gas stream (tunable diode laser TDL, *mettlertoledo*), online gas chromatography for product gas analysis up to chain lengths of C_{20} (Nexis GC-2030, *Shimadzu*) and finally an IR-spectroscopy to determine CO and CO_2 concentration in real-time (Uras26, *ABB*). Liquid samples can be collected in two separators and be analyzed offline. The plant is fully automated via Simatic PLC and can be operated remotely. Depending on the gas flows, steady state can be achieved in less than 4 h of operation.
During the commissioning and first experimental campaign, a supported Fe-based catalyst was successfully reduced in-situ. Reduction and activation was monitored via TDL and verified by GC measurements. After a parameter study with variation of temperature, pressure, H_2:CO_2 feed ratio and GHSV, of >300 h of operation, no significant deactivation or change in product spectrum was observed. A simple kinetic model to describe the reaction rates of rWGS and FTS was taken from literature and adapted to the 11 different conditions. The model showed a mean deviation of less than 10 % while only having 6 parameters fitted.
In future work, the model will be extended to describe product distribution and be used for reactor

modelling of SBCR. In the plant, different catalysts will be examined regarding their suitability for three-phase direct CO_2-FTS with special regard to in-situ reduction and activation, effect of quantified H_2O partial pressures, load changes, product distribution and kinetics.

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Short biography: Philipp Graefe was born 1997 in Schwerte and studied Chemical Engineering at TU Dortmund from 2014 until 2020 when he was awarded the degree M.Sc. During his studies, he received numerous grants, e.g. the “Wacker Preis” for the best Bachelor, and took part in exchange programs Sweden Japan. After finishing his Master thesis on “Investigation of Reaction Kinetics and Interfacial Phenomena in Multiphase Catalysis” at the Max-Planck-Institute for chemical energy conversion, Philipp Graefe commenced his PhD studies at Karlsruhe Institute of Technology (KIT) in 2021. There, his research focuses on three-phase CO_2-Fischer-Tropsch synthesis in the frame of the InnoSyn project.

Investigation of thermal decomposition characteristics of Turkish biomass samples by thermogravimetric analysis and Fourier Transform Infrared Spectroscopy*

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Abstract:

In this study, the pyrolysis characteristics of four local biomass samples (pistachio shell, walnut shell, poppy capsule pulp, tea pruning waste) were investigated under nitrogen (N_2) and carbon dioxide (CO_2) atmospheres, by using Thermogravimetric Analysis (TGA) coupled with Fourier Transform Infrared (FTIR) analyser. Biomass samples were characterized in terms of elemental analysis, ultimate analysis, calorific value, inorganic content and anion/cation composition. The samples showed different pyrolysis characteristics depending on their lignin, cellulose and hemicellulose contents. TGA-FTIR analyses indicated that the thermal degradation products depend on the pyrolysis temperature, gas atmosphere and physicochemical properties of biomass samples. Generally, carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), methanol (CH_3OH), H_2O, hydrocarbon compounds with carbonyl and ether/amine bonds and were observed as decomposition products. The thermal degradation behaviour of biomass samples were determined to be independent of the gas atmosphere up to ~800 °C. In CO_2 atmosphere, all samples exhibited an extra weight loss around 800 - 850 °C, different from the N_2 atmosphere, due to the reactions between CO_2 and gas, char, as well as tar components formed during decomposition, confirmed with FTIR analysis.

Acknowledgments: The experimental part of this study is supported by the Presidency of the Republic of Türkiye, Strategy and Budget Directorate, within the scope of Advanced Coal Conversion Technologies (2016K121340) project.

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Short biography: She has more than 15 years of research experience based on biomass thermochemical conversion processes, particularly pyrolysis, gasification, and chemical-looping combustion technologies. She is working as a chief senior researcher at TUBITAK Marmara Research Center, Clean Energy Technologies Research Group. She managed/participated various national and international research projects funded by Government of Turkiye and European Union.

Refineries as green hydrogen technologies' incubators (GH2T)

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Abstract:

The availability of residual biomass in the province of Andalusia, which can be revalued for energy purposes, makes this resource in the province one of the keys to the approach towards the energy decarbonisation of the autonomous community. This, combined with the existence of two important chemical poles in Huelva and Algeciras, which demand a large amount of energy and possess technological know-how, make the area of western Andalusia a strategic enclave for accelerating the implementation of sustainable energy-producing technologies. This, coupled with the fact that hydrogen is seen as a promising solution for the energy system of the future, makes the study of green hydrogen production technologies with biomass an attractive approach to the decarbonisation of the energy system. Therefore, the general objective of the work (within the framework of the national GH2T project) is to set the path for the transformation of refineries in Europe into hydrogen clusters for incubation of green hydrogen technologies, while considering its current and future complexity (i.e., decarbonization).

The production technologies considered in the study for the production of green hydrogen were electrolysis, bioethanol and biogas reforming, biomass gasification, solar-assisted biomass gasification to hydrogen and dark fermentation. Additionally, to avoid possible lock-in effects, this project also considers the integration of bio-oil processing technologies, which come interesting in terms of decarbonization, when combined with green hydrogen. In this respect, the technologies considered have been biomass pyrolysis and hydrothermal liquefaction.

Beyond the technical approach to hydrogen production, the study of the different alternatives will take into account both the social and environmental impacts that may be generated and the contribution to policy making regulating the context of the bioeconomy (and more specifically, the hydrogen economy). Based on the different approaches mentioned above, the following specific objectives have been defined to achieve the general objective of the GH2T project:

- Identification of opportunities, challenges and synergies for integrated renewable hydrogen production in Refineries considering their expected evolution in terms of decarbonization (technical perspective).
- Conceptual design of the integration of the technologies covered in two Case Studies (examples of refineries) considering large-scale storage and enhanced hydrogen networks.
- Critical evaluation (along the project) of the sustainability of the conceptual designs prepared.
- Contribution to policy making in the framework of the hydrogen economy and its integration into existing industrial activities.

- Creation of a realistic exploitation roadmap for the results of the project.
- Maximizing the contribution to the Sustainable Development in terms of economic, social, and environmental sustainability.

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Characterization of co-products from the aqueous waste stream generated during the wood thermal modification process

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Abstract:

Several chemical-free processes have been developed in the wood processing industry to improve the durability and to optimize the service life of wooden elements in exterior conditions, including thermal modification of the material at different temperatures and atmospheres. The hygrothermolytic modification process (patented as Firmolin) represents thermal modification of wood among the industrial treatments. The solid wood is modified in a pressurized unsaturated steam atmosphere at moderated temperature (<180 ºC) controlling the water activity during the chemical reactions that occurs during the process (hydrolysis, dehydratation and cross-linking). The thermal modification process generates secondary aqueous streams containing heterogenous mixtures of organics from the treated wood material. Such residuals might be valuable source of bio-based chemicals, being an interesting valorization strategy of industrial co-products instead of requiring a wastewater treatment. Essentially, the generated fluid represents the cooled condensate of the steam exhaust, which is composed mainly by water from the steam supply and from wood (desorbed and reaction water), combined with volatile organics (thermal reaction products and natural extractives). In this research, the raw fluid generated during the hygrothermolytic modification of Radiata pine (*Pinus radiata*) wood was collected directly from the steam condenser outlet and characterized. The aqueous waste was filtered (separating water soluble and insoluble fractions) and the physical properties were measured (concentration, pH, viscosity). Moreover, the chemical composition of condensates (soluble and insoluble fractions) was identified by GC-MS, determining the polar and apolar compounds present on each fraction. The results showed an acidic (pH≈2) and non-viscous liquid which contains functional groups from the breakdown of hemicelluloses such as carboxylic acids and acetyl groups. Specifically, the main compounds present in both fractions belong to the categories of terpenoids, acids, polyphenols, and alcohols, while furanic compounds were present in the highest concentrations. In addition, the polar fraction (DCM soluble compounds) resulted in a higher presence of acids, alcohols, and polyphenols, however, terpenoids were the main components of the apolar fraction (hexane soluble compounds). Despite the high heterogeneity of the product streams, few compounds dominated the mixtures and those could be isolated by cost-competitive processes, such as liquid–liquid extraction, distillation and/or recrystallization. Consequently, is possible to obtain valuable chemical co-products from the residual streams allowing a better waste management strategy.

Details of presenting author

Name: **Rene Herrera**
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Short biography: I am postdoctoral researcher from Chemical and Environmental Engineering Department at the University of the Basque Country UPV/ EHU (Spain), working on the substitution of traditional materials derived from fossil resources by bio-based materials like wood and wood-based products. My research objectives are to improve the properties of these materials by adding new functionalities and using the best practices of sustainable management in the processes, as well as the use of clean and non-intrusive advanced analytical methodologies for the control of the processes and final products.

A Swedish perspective on decarbonization of industry through the development of biorefinery technologies

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Abstract:

Sweden aims for zero-net emissions of greenhouse gases by 2045; As such, deep decarbonization of the society requires reconsidering the production routes, and the corresponding value chains, with a radical switch to renewable carbon, utilizing all available indigenous biogenic waste. Biorefineries represent an integrated approach promoting bio-based economy (BBE).They set the basis for an energy-efficient and carbon-neutral industry offering a plethora of solutions for producing industrially important chemicals (IIC) and energy carriers, utilizing common infrastructure.

The latter can reduce costs, hence making investments more attractive, accelerating the transition. Moreover, CCU technologies can add to the diversity of the feedstock improving the security of supplies and enabling synergies with other energy systems.

While the focus has been put on biofuels which can decarbonize the transport sector, the emerging electrification of the vehicle fleet can turn investments and infrastructure obsolete. Therefore, flexible production routes that enable parallel production of chemicals will provide a holistic approach towards the 2045 goal.

The poster summarizes results and research of on-going and recently completed projects and biorefinery approaches (i.e., thermochemical (pyrolysis-gasification) and alcohol-based biorefinery) that have been developed together with industrial partners in Sweden. Synergies with CCU technologies as well as green H_2 are also presented. Emphasis is put not only on the process itself but also on the efficient reactor design and process intensification for improving product selectivity and energy demand.

The first part presents a combined pyrolysis-gasification concept where, contrary to traditional routes for production of renewable transportation fuels from biomass waste, the production of highly valuable intermediates such as light olefins (C_2-C_4) allow highly flexible and selective production of diesel and/or gasoline via the Mobil olefins to gasoline and distillates (MOGD) process. This process scheme is advantageous because it can produce very valuable intermediates (olefins) and therefore can benefit the chemical industry as well; small to medium plant sizes were considered in the study (5-50 MW_{th} of biomass heating value).

The second part deals with the development of and alcohol-based biorefinery able to produce 50ktpa of high value specialty chemicals and fuels from inexpensive, and simple alcohols, methanol (MeOH) and ethanol (EtOH). The selection of the processing schemes and intermediates allow the integration with CCU as well as green-/bio-H_2 and biogas which are also produced within the system boundaries, allowing for a fully integrated sustainable system. More specifically, debottlenecking of the routes for production of C_{4+} products and utilization. Such modular biorefinery is expected to achieve CO_2 savings ranging between70 and 75 ktpa.

Details of presenting author

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Short biography: Associate Professor at KTH Royal Institute of Technology, Department of Chemical Engineering with specialization in chemical reaction engineering and reactor design. Main research interests include chemical reaction engineering and heterogeneous catalysis focusing on the development and optimization of sustainable processes with renewable feedstocks/products. Olefins oligomerization, CO_2 utilization, C-C coupling, hydrogenation, and chemical storage of H_2 are some of the topics I currently work with. > 30 peer-reviewed publications, 3 book chapters and > 50 presentations in conferences. Diploma in chemical engineering from Aristotle University of Thessaloniki. Licentiate of engineering in thermochemical treatment of waste and PhD in catalytic process engineering from KTH.

Hydrothermal treatment of biomass waste to produce hydrochar and artificial humic substances

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Abstract: Biomass waste as a by-product of food production and consumption, agriculture, forestry is a significant problem, considering amount and adverse impacts on environment, especially impact on climate. The biomass waste management problem becomes yet more urgent considering aim to abandon fossil material-based production and promote bio-based economy – bioeconomy and achieve climate neutral and resource saving development. As a tool of climate-neutral processing of biomass waste can be considered hydrothermal carbonisation at 180 – 250 °C in presence of water and a catalyst. The yields and properties of produced hydrochar, high molecular substances present in process waters (artificial humic substances) depending on the conditions of hydrothermal carbonisation and biomass type has been discussed. Significant differences, depending at first on the precursor material has been found using thermogravimetric analysis, FTIR, NMR, SEM and other methods. The application possibilities of hydrothermal carbonisation products have been demonstrated for trace element and organic pollutant sorption. As highly prospective can be considered the use of hydrochar for carbon capture. The carbon dioxide sorption capacity can be increased using hydrochar modification (N-doping) as well as activation to form biochar. Hydrochar as well as its modification products demonstrates high sorption capacity (up to 5 mmol CO_2/g), good recycling efficiency and recycling stability.

Details of presenting author

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Short biography: Research interests includes environmental pollution analysis, biomass waste processing, biorefinery of biomass, especially valorization methods.

Biofuels and value-added products for energy conversion and storage

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Abstract:

Climate change and the decreasing availability of fossil fuels drive society to seek sustainable and renewable energy sources. There is a need for proper managing of diverse energy conversion and their efficient storage. The major research and development efforts in the EU focus on developing new industrial-scale technologies able to produce sustainable bioenergy from biomass material which are treated as a food waste. Biomass, the most abundant renewable source of carbohydrates as fuels is very attractive opportunity under green chemistry routes to lead to a sustained circular economy perspective. To overcome the current energy problems, it is predicted that lignocellulosic biomass in addition of green biotechnology will be the main focus of the future research areas. Green chemistry related synthetic concepts will be utilized for the production of cheap and environmentally friendly bio-waste-derived carbonaceous electrode materials. The increased availability and decreased cost of biomass make it a promising platform molecule to produce a wide range of value-added chemicals and fuels via the thermal conversions.

The aim of the project is to investigate the hydrothermal carbonization (HTC) as a way towards sustainable biorefinery technologies for (i) biochar – carbonaceous species, and (ii) value-added chemicals and fuels. HTC of biomass entails thermochemical conversion process of wet biomass feedstocks, over a wide range of hydrolysis, dehydration, and decarboxylation processes which leads to chemicals/fuels such as mainly 5-hydroxymethylfurfural, furfural, levulinic acid, carbon nanodots, and a solid biochar. The main benefit from the project is the contribution to the development of carbonaceous materials and chemicals over HTC approach and promoting synergies on a global scale with corresponding directly to EU priorities and within goals of sustainable development, especially, the European Green Deal.

Details of presenting author

Name: **Maria K. Kochaniec**
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Short biography: Maria Kochaniec received her Ph.D. degree from the Gdansk University of Technology, Poland, in 2018. Maria conducted research in Poland and abroad (Germany, United Kingdom and South Korea) to gain experience in scientific and R&D projects thus creating a bridge between Academia&Industry. She is currently an Assistant Professor at Warsaw University of Technology, Poland. She is interested in the batteries systems through design of novel and innovative electrode materials, including but not limited to carbonaceous framework received from biomass processing. Her recent research is being conducted through the **CELISE** (celise.unican.es) project, which is within the European Union's Horizon 2020 program, Maria Skłodowska-Curie Actions – RISE (grant number 101007733).

Hydrothermal Carbonization (HTC) of dairy waste: Effect of temperature and initial acidity on composition and quality of products

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Abstract:

The expansion of milk production in the EU is trailed by a significant increase in dairy processing waste (DPW), which raises the need for dairy waste management. Furthermore, DPW was recognized as a potential feedstock of STRUBIAS (STRUvite, BIochar, or incineration AsheS) products, which are capable of fertilizer applications and soil amendments. Hydrothermal carbonization (HTC) of dairy processing waste was performed to investigate the effect of temperature and initial pH on the yield and composition of the solid (hydrochar) and liquor produced. Maximum hydrochar yield (61%) was observed at T=180℃ and pH=2.25, whereas the maximum P-recovery was 80% at T=220℃ and pH=4.6. All hydrochars met the EU requirements of organo-mineral solid fertilizers defined in the Fertilizing Product Regulation in terms of phosphorus (P) and mineral content. The heavy metal content of the hydrochars was mostly compliant with EU limitations. For the liquid product, the increase in temperature beyond 200℃, coupled with an increase in initial acidity (pH=2.25) drove P into the liquor. Simultaneously, increasing HTC temperature and acidity increased the concentration of NO_3^- and NH_4^+ in the liquid products to a maximum of 278 and 148 mg/L, respectively, at T=180℃ and pH=4.6.
One of the approaches for measuring the potential of hydrochar as a fertilizer component is its phosphorus content. According to Product Function Cat.1(B)(I) specified in Annex I in EU Regulation 1069/2009, a solid organo-mineral fertilizer consisting of multiple nutrients must contain at least 2% by mass of total P_2O_5. Experimental results showed that the initial dairy waste contains 5.7% of P on a dry basis. Thermochemical processing offers a route for waste valorisation and nutrient recovery from products.

Details of presenting author

Name: **Witold Kwapinski**
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Short biography: Dr. Witold Kwapinski works as an Associate Professor at the University of Limerick in the Department of Chemical Sciences. He completed a PhD in the area of Chemical Engineering. Witold is Course Director of the IChemE-accredited Chemical & Biochemical Engineering (HonsBEng) programme. Witold 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 4 as a co-supervisor. In the past he successfully supervised 14 PhD students. He is author of over ninety papers in ISI journals (h-index = 33 in 2023).

Techno-economic aspects of biogas among IPPC pig farms in Serbia

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Abstract:

Serbia is a country with a long tradition in agriculture, which is considered a strategically important sector of the national economy. Large farms to which Law on integrated pollution prevention and control (IPPC) applies comprise 40% of all IPPC installations in the country. Recent energy policy legislative induced favourable conditions for export of electricity through feed-in tariffs, which resulted in a growing number of biogas installations in the country with new installations estimated at 50 MW in total for the period 2016 to 2020. However, by imposing the new EU circular economy value chains in line with the Green Agenda for Western Balkans, the profitability of the biogas installations has changed, imposing investment difficulties for Serbian operators. By analysing 48 pig farms on the official IPPC installation list of the Ministry of Environmental Protection of the Republic of Serbia, existing potentials for biogas production are estimated based on the amount of generated manure, farm type and potential influence of regional arable land crop residues. Intensive rearing farms showed 4.3 times greater potential for electricity production, compared to reproduction and fattening farms. Biogas cogeneration is considered one of the Best Available Techniques (BAT) for solving problems with storage facilities of generated manure, if the issues of substrate and land spreading are planned as part of the biogas planning project. A techno-economic optimization of an intensive rearing pig farm is performed, based on real farm by-product stream data, and annual dynamic typical meteorological year simulation of a cogeneration internal combustion engine biogas system using TRNSYS software. The results take into account the impact of the energy demand side annual dynamics to the profitability of the installation, while it is assumed that the substrate produced during the biogas production process is applied as fertiliser on the farms own land with no profit, corresponding to a typical scenario of an integrated IPPC farm in Serbia. The results indicate the impact of local energy demands (heating, cooling and electricity) on the financial feasibility of biogas cogeneration plants with market conditions. The power rating of an economically feasible solution is limited by the local energy demands with the lack of market and technical possibilities to export heat, due to the distance of rural locations of the case study farm, which may be considered similar to typical location conditions of IPPC farms in Serbia.

Details of presenting author

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Short biography: Dr Marko Mancic is head of the teaching laboratory for Energy and Process engineering, a teaching assistant and a postdoctoral researcher at the University of Nis, Serbia. Research interest are techno-economic optimization and integration of complex multi carrier renewable energy systems, circular economy and regional energy planning. Recent research activities aim toward development of zero net energy and zero waste devices and solutions.

Biodiesel production, using heterogeneous catalyst and waste from the aquaculture industry: Conceptual processing plant

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Abstract:

Due to the increase demand for sustainability and reuse of materials is that waste valorization is getting more and more attention, from a research perspective as well as from industrial point of view. It is relevant for society as it promotes sustainable use of resources, reduces environmental pollution, and creates economic opportunities through the generation of new products and industries.

In addition, the growing demand for energy worldwide due to the industrialization as well as the economic growth has put pressure on the reuse of waste into new products due to the limitations of resources.

Among the possible renewable energies available, liquid biofuels still have a market and a need due to their use as a replacement for petroleum fuel. In particular, biodiesel has shown great advantages to be used as a substitute for petroleum diesel as a fuel for trucks, boats, and smaller vehicles.

A processing plant to convert a waste oil into biodiesel using a renewable and sustainable catalysts is presented here. The oil used was waste fish oil in the presence of bio-butanol and calcium oxide (CaO) as catalysts. In this work, the design of a new processing plant that could allow the use of the by products produced from the biodiesel industry (Glycerol) to be used as enrichment materials for the CaO to improve its catalytic properties is presented. This was achieved by recycling catalyst through calcination and re-enrichment side unit.

The total amount of biodiesel, as well as the energy required was estimated based on a production year. The total production of biodiesel was estimated to be 17326.77 m^3, with a total energy consumption of 876.04 MWh.

Details of presenting author

Name: **Jorge Mario Marchetti**
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Short biography**:** Dr Jorge Marchetti is a professor and the leader of the reaction engineering and catalysis group at the Norwegian University of Life Sciences in Ås, Norway. He is an expert on renewable energy, biofuels, green chemistry, and processing system engineering. His work focuses on the valorization of waste biomass and its transformation into biochemicals, biofuels, and bioplastics following a biorefinery concept approach. His work is also related to the development and application of catalysts, kinetics, processing modeling, and techno-economical assessments.

Lignin valorization towards fuels, chemicals and polymers

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Abstract:

Lignocellulosic biomass from agricultural/forestry residues, food processing industry and municipal wastes, is considered as an alternative to petroleum, renewable source of fuels, chemicals and polymers. Within the biorefinery context, whole-biomass valorisation is targeted by applying atom and energy efficient green processes with minimum environmental impact. Lignin is considered as the most abundant natural source of aromatic/phenolic compounds. Multiple biorefinery and industrial processes lead to the isolation various types of lignins i.e., organosolv, hydrolysis, kraft, lignosulfonates etc. Lignin properties depend on the biomass nature/type and the isolation process, which affects their reactivity via the aliphatic and phenolic hydroxyl, carboxyl, ether and aldehyde groups, as well as their molecular weight and homogeneity.

The most important step in biorefining is *biomass pretreatment* towards the selective fractionation of the structural components (cellulose, hemicellulose and lignin). *Hydrothermal pretreatment* in neat water under relatively intense conditions can be applied to selectively recover hemicellulose in the liquid fraction, as xylose monomers and degradation products (HMF, Furfural, organic acids, etc.). *"Surface" lignin* recondensed on biomass particles can be extracted with green and easy recoverable solvents (i.e. ethanol). "Surface" lignins exhibit low molecular weights and low β-O-4 interunit linkages. Alternatively, *organosolv pretreatment* in ethanol-water mixtures is applied to isolate lignin in one step. Delignification is increased using dilute sulfuric acid during the pretreatment. Organosolv lignins exhibit lower molecular weights than other technical lignins and more β-O-4 interunit linkages.

Lignin depolymerization into phenolic/aromatics monomers can be achieved via fast pyrolysis and hydrogenolysis. Thermal fast pyrolysis leads mainly to bio-oils enriched in alkoxylated phenols while aluminosilicate catalysts can in-situ upgrade the vapours towards alkylated phenols, BTX aromatics and naphthalenes. Lignin composition, in terms of S/G ratio, is "transferred" in the bio-oil composition which can be controlled via pyrolysis temperature and catalysts properties (acidity, porosity, etc.). Alternatively, the phenolic bio-oils can be ex-situ hydrodeoxygenated using bifunctional catalysts, i.e. Ni on zeolitic supports or mesoporous mixed oxides/spinels, towards C_6-C_9 (cyclo)alkanes which can be utilized as drop-in fuels. Hydrogenolysis of lignin using hydrogen donor solvents and metallic catalysts supported in micro/mesoporous carbon can also lead in phenolic bio-oils. Lignins with high β-O-4 interunit linkages content and low molecular weight are preferred for lignin hydrogenolysis.

Alternatively, lignins can be utilized in various polymers and composites (i.e., epoxy resins, phenol-formaldehyde resins etc.), due to their similarity and versatility in terms of phenolic structure and functionality. The lignin-epoxy composites may exhibit improved tensile and thermal

properties as well as transparency, while the composite preparation may also be achieved without any solvent or need for prior functionalization of lignin. Additionally, kraft lignin from the pulp industry can also be utilized in epoxy resins as an additive either as-isolated (Kraft) or after functionalization (i.e., glycidylation-GKL) or after mechanical treatment to reduce particle size and facilitate dispersion. Lastly, lignin and lignin monomers due to their phenolic nature can be utilized in phenol-formaldehyde resins (PF) towards replacing fossil-sourced phenol.

Details of presenting author

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Short biography**:** Dr. Antigoni Margellou has received her Bachelor, MSc and PhD from the Department of Chemistry, University of Ioannina. Currently, she is a postdoctoral researcher at the Department of Chemistry, Aristotle University of Thessaloniki. Her main research interests focus on the characterization and fractionation of lignocellulosic biomass feedstocks and their downstream valorization via catalytic processes (catalyst design/characterization, pyrolysis, hydrogenolysis/hydrogenation). As a research fellow, she has participated in 7 long-term research projects, has co-authored 22 publications in international peer-reviewed journals and books, over 85 conference proceedings and 1 patent.

Synthesis and characterisation of graphene based-polymeric aerogels

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Abstract:

Water treatment is a big concern for many scientists. Oil spills are a major threat for both the environment and the people; thus, it needs to be dealt with. Some potential oil spill cleanup methods are chemical dispersions, oil booms, skimmers and in-situ burning. However, the aforementioned techniques have some restrictions, which have created difficulties over the years. For this reason, the present paper suggests the use of aerogels, which are characterized as hydrophobic, in order to absorb only the oil. Absorption with porous materials is preferred because of in-situ absorption, efficient oil recovery and minimal use of energy. The aerogels we fabricated are non-toxic, biodegradable and light weight. For their synthesis, chitosan, PVA, graphene oxide and reduced graphene oxide aqueous solutions were used in different ratios, with GLA being the cross-linking agent. Aerogels were obtained through the freeze-drying method. Novel CS/PVA/GO and CS/PVA/rGO were fabricated. FTIR and XRD analysis confirmed the synthesis.

Details of presenting author

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Short biography**:** I studied Chemistry in the Department of Chemistry of Aristotle University of Thessaloniki. During my first years, I found the industrial part of chemistry intriguing, in particular polymers, and that's why I chose to specialize in Chemical Technology and Industrial Chemistry. Currently I am pursuing a Master's Degree in Oil and Gas technology and I am doing research on chitosan and graphene-based aerogels for oil absorption.

Production of pyrolysis oil from municipal wastes

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Abstract:

In Switzerland, as in some other industrialized countries, municipal wastes are eliminated by incineration with thermal energy recovery for power production and district heating. A renowned ski resort contacted Greenlina to evaluate the feasibility of pyrolyzing garbage bags collected by the city to produce liquid and gaseous fuels. Greenlina has developed and patented a medium temperature (about 400°C) pyrolysis and refining system using high power electromagnetic heating to achieve high efficiency, low energy consumption, zero pollution and zero emissions throughout the production process. It is a batch system with an overall processing time of about 4 hours (including loading and unloading). The reactor can be fed with any organic based material such as plastic and food wastes, rubber, paper etc. The industrial size system allows the treatment of PVC, thanks to a dechlorination step.
In addition to the 2 m^3 batch reactors (containerized), the company has built a small batch reactor of 5 litres to test various feedstocks, shown below on the left. The reactor temperature rises rapidly, and it can reach the thermal cracking temperature and produce crude oil in a very short time (about 15 minutes to start generating crude oil).
A first demonstration was carried out with a garbage bag sample (shown below on the right) composed mainly of plastic, metal, and food waste. The sample was weighed before and then inserted into the reactor. After the reaction, the different products were collected and weighed to establish a mass balance.
In the experiment a three-step heating method was used: the temperature for heating is first set at 270°C for 50 minutes and then at 320°C for another 50 minutes. These temperatures can be adjusted as required during the experiment, depending on the amount of steam produced. During these steps the following processes occur:

- melting the waste and converting the long-chain molecules into short- chain molecules.
- converting the volatile components of the sample into pyrolysis vapours and passing them into double separation tank.
- Then the third stage, where the temperature is increased to 350°C, serves to completely volatilize the oil vapours and complete the pyrolysis reaction, leaving only solid residues in the reactor. Once the three stages are completed, the heating is stopped, and the cooling phase of the reactor is initiated and lasts until it reaches room temperature.

The various fractions obtained from a sample of 764 grams were:

- pyrolysis oil: 37.8%
- Water: 8.1%
- Solid residues: 18.5%
- Non-condensed gases (by difference): 35.6%

The oil yield is slightly lower than that obtained from the pyrolysis of plastic waste, as the sample also contained wet food wastes, as well as metals. The proportion of solid residues, 18.5%, is relatively consistent with the other samples tested. The metals can be separated beforehand, which would reduce the solid fraction and increase the liquid and gaseous fraction accordingly, or they can also be separated in the post-treatment. The separated metals can then be recycled. The possibility of post-treatment of the solid carbonaceous residues by using them as raw materials is being studied.

Details of presenting author

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Short biography:

Expert and consultant for the energy recovery of waste and new energy technologies.
Training engineers in renewable energies, bioenergy, and waste recycling.
Ph.D. in Energy technologies (Valenciennes, 1983), he has been full professor at the University of Applied Sciences and Arts Western Switzerland from 2004 to 2018 where he initiated and led many R&D projects in the field of energy and environment, especially for biomass and waste recovery. He is also a member the Advisory Board and expert at Race for Water Foundation and Solar Impulse Expert for the World Alliance for Efficient Solutions. linkedin.com/in/jbmichel1

Evaluation of thermal characteristics of different sources of bio-feedstock for solid fuel and pyrolysis boilers

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Abstract:

Cultivation of energy crops and fast-growing trees on marginal lands makes sense to investigate the use "waste nutrients" that are locally or regionally available to promote high yields of bio-feedstock. The high productivity of energetic plant plantations can be provided through the use of the municipal sewage sludge as fertilizer. The amendments indirectly affected the thermal stability of Miscanthus and Switschgrass biomass at the initial stage of thermolysis. The greatest modifications are characteristic for leaf biomass and are associated mainly with the decomposition of volatile components and hemicellulose, as well as with the formation of an unburned residue.
Ukrainian and American sweet sorghum hybrids were studied as raw material under reclaimed lands conditions in the southeast Ukraine. Among the cultivars in the range of hemicellulose destruction the highest reactivity was recorded for American hybrids, whereas the process of cellulose decomposition was most active in Ukrainian hybrids. TG curves of Ukrainian hybrids were more differed for plants grown on loess like loam comparative with American hybrids. Thermal analysis of sweet sorghum biomass, sewage sludge, and composite mix of sludge and biomass showed the almost complete absence of sludge thermal degradation. Addition of the plant biomass to sludge activates the thermal behavior of the composite mix, as a result, the combustion level rises to 41.4%.
A preliminary analysis of the influence of species belonging, soil, climate conditions and wood age on the thermal characteristics of wood biomass was carried out. In the range of holocellulose destruction, Salix, Populus, Ailanthus, Elaeagnus and Paulownia clone 112 wood has only one peak, because of the large amount and specific composition of hemicellulose. Given the same genetic component of the studied plants, deviations in the thermal characteristics of the samples can be explained by the heterogeneous chemical composition of the soil, kind of amendments (sewage sludge, biochar) which affects the wood calorific value.
The specific properties of Technosols have a certain influence on the thermal characteristics of the biomass of herbaceous and woody plants. The duration of thermolysis changes. There is a shift in the decomposition intervals of hemicellulose and cellulose, and variations in the fractions of the residual mass after the combustion of raw materials. Small changes in activation energy indicators are also possible. Volatile components of biomass are mainly affected as substances most sensitive to environmental conditions. They, in turn, affect the speed of reactions and the thermal stability of wood and grassy biomass.
Agricultural residue/wastes are promising for producing bioenergy, despite the existing considerations, such as spatial distribution, production costs, and an unstable supply. Availability

of the feedstock and regional concentration are good preconditions for local bioenergy generation. The pilot scale study was dedicated to establishing of dependencies of the process parameters on the composition of pyrolysis products and finding of the optimal process intensity to obtain certain gaseous products composition.

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Fine particulates in flue gases of biomass refinery

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Abstract:

Biomass refinery aims utilizing any kind of biodegradable residue, obtained from different economical sectors. Processing such residue to materials of various applications assures its further implementation directly or after transformation and significantly reduces the amount of substance to be dumped. Biomass thermo-chemical conversion involves processes like: pyrolysis; carbonization; combustion; gasification; liquefaction; hydrothermal treatment or others. Despite the chosen technology, the pollution emissions still need to be controlled.

The present summary refers to several case studies of experimentally measured particulate matter (PM) in flue gases generated during biomass thermochemical conversion. The experiments were carried out in collaboration initiatives involving experts from several European research organizations. For that purpose different types of laboratory-scale reactors were used (formation rate unit, drop tube furnace, fixed bed reactor and tubular flow reactor) at atmospheric pressure; temperature up to 1100 ℃; variable air flow rate and air equivalence ratios. The purpose of these studies was to control pollutants emitted while utilizing lignocellulosic biomass residue with agro-forest origin, which was obtained from several EU countries or solid biofuels, available at the Bulgarian energy market. In focus were the primary gaseous products as well as the PM, known for having significantly negative impact on environment and human health. As expected, the chemical analysis of PM has shown significant concentration of absorbed hydrocarbon, such as polycyclic aromatic hydrocarbons (PAH).

The experimentally measured PM number density or mass were detected using spectroscopic and gravimetric analyses. Thus, $PM_{10 \div 0.016}$ with different cut-diameters (cut-off sizes, between 10 μm and 16 nm) were determined assuring 50 % efficiency of the PM sampling procedure. The results confirmed that the concentration of ultrafine (submicron sized) particulates ($PM_{\leq 1}$) is often dominating over the fine particulates ($PM_{10 \div 2.5}$) in the examined flue gases. Significant interest deserved the results from the PM chemical characterization, applying different nondestructive analytical methods (e.g. SEM-EDS; XRF, XPS, EPR and other). For instance, the results from SEM/EDS and XPS analyses showed that the ultrafine $PM_{\leq 1}$ usually contained more than 80 % of carbon. This was considered to be mainly soot and hydrocarbons, formed due to the incomplete biomass oxidation. In addition, elements like potassium and chlorine were typical constituents of the ultrafine PM. The elevated PM emissions were also found to correlate with the high content of volatile organic compounds, obtained in the proximate analysis of the utilized biomass residue/blends of solid biofuels.

Acknowledgments: This work has been carried out in the framework of the National Project "AEROSOLS and their Organic Extractives, derived during Biomass Conversion – Cytotoxic and Oxidative Response of Model Systems of Pulmonary Cells", Contract № КП-06-Н44-5/13 since 14.07.2021, approved by the National Science Fund (NSF), Ministry of Education and Science (MES) as well as Contract № КП-06-КОСТ/12, 16.12.2021 for national co-financing the participation of Bulgarian collectives in established actions under the European Program for Cooperation in Scientific Research and Technology (COST), approved by NSF, MES.

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Refuse derived fuel as feedstock for waste-to-energy systems – The AmbWTE project

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Abstract:

Waste production has followed an increasing trajectory because of population growth and technological and social development. This trend is currently reaching very significant impacts in overall society, mostly due to the high waste quantities that are produced and the existence of toxic and pathogenic agents, both factors posing high risks to the environment and human health. By 2016, Portugal produced 4.9×106 t of Municipal Solid Waste (MSW), 2.6×106 t of Construction and Demolition Wastes (CDW), and 119×103 t of wastewater treatment sludge. As such, Waste-to-Energy (WtE) technologies are progressively being studied and implemented in waste management, aiming at producing energy, materials and increasing value from wastes.

The residual, non-hazardous organic fractions that can be separated from MSW or CDW (and industrial wastes) can be processed to obtain a waste derived fuel (WDF). Refuse Derived Fuel (RDF) is one type of WDF with characteristics that are more suitable for Waste-to-Energy applications than non-treated waste. In the case of Portugal, 683 t of RDF were produced in 2019. The production potential of this fuel in the national territory is much higher, but it was hindered by its high moisture and chlorine contents. Nevertheless, RDF may constitute an alternative raw material with greater interest for Waste-to-Energy applications, which may promote the development of new economic markets associated with waste.

The AmbWTE project aims to develop an innovative combined cycle gasification system that can be fed with different heterogeneous feedstocks, namely a fuel mix mainly composed by RDF (mixed with other waste flows, e.g., lignocellulosic wastes or sewage sludge). The goal of AmbWTE is to achieve a WtE system that operates continuously with small amounts of waste and that is based on the reuse of syngas to produce electrical and thermal energy, reducing the environmental impact of this process, and contributing to the efficiency and energy autonomy of waste management companies. Moreover, this concept will also produce biochar, with improved properties, that can have other industrial applications, namely as an adsorbent or as solid fuel for boilers.

Overall, AmbWTE will contribute to the transition from the linear model of production of goods and services, to a circular model (Circular Economy), allowing waste to be transformed, through innovation, into potential by-products or energy with low carbon footprint.

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Carbonization tests for energy recovery of electric cable insulation waste

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Abstract:

Biochars were produced at different temperatures, namely 300, 350 and 400 °C. For the production of biochar, lignocellulosic biomass residues and electrical cable insulation residues were used. The produced biochars were submitted to a washing process with water heated to 95 °C ± 5 °C and characterized. The biochars after being washed, passed through an activation process with 2N KOH, were also characterized. All biochars were characterized by elemental analysis, thermogravimetric analysis, calorific value, chlorine removal, amount of ash, bulk density, and surface area. With the characterizations it was possible to conclude that the increase in temperature from 300 to 400 °C causes the produced biochars to present a lower amount of oxygen, lower percentage of volatile matter, higher calorific value, greater removal of chlorine, greater amount of ash. The activation process increases the surface area of biochars as the production temperature increases.

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Solar-aided hydrothermal liquefaction of agricultural waste

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Abstract:

Hydrothermal liquefaction technology (HTL) is the thermochemical conversion of high moisture organic waste into biocrude without the need for the expensive step of feedstock dehydration [1,2]. Sub- or supercritical water conditions (250-550 °C, 5-25 MPa) are used to induce the macromolecules decomposition and oil compounds formation by repolymerization of unstable fractions [3]. Products occurring from this process include a gas phase, a solid residue, an aqueous phase, and biocrude, a dark viscous oil which can be further upgraded to attain properties similar to hydrocarbons [4,5]. Agricultural waste contain a significant amount of organic content and could effectively be valorized to the production of added value products.
The current study focuses on the HTL process of essential oils production residues. The experiments were held under temperatures that ranged from 300 to 375 °C and two initial pressures (1, 20 bar). N_2 was used as purging gas in a 1.8 L autoclave reactor including an electric heater, and the experimental procedure was held with a retention time of 30 min.
Different heating means were compared and verification of the results were achieved by repeating tests using an in-house solar simulator as the thermal energy provider. The temperature and pressure rise rates accomplished this way were 6.2 °C/min and 3.5 bar/min, significantly increased than the corresponding ones attained with the electric heater (3.2 °C/min and 1.9 bar/min).
Feedstock and products composition were studied and compared by the determination of Higher Heating Value (HHV) and elemental analysis. Gaseous products were also characterized in terms of Gas Chromatography (GC). According to the results, biocrude yield reached ~55%, while it increased by a maximum of 9% when tested in the solar simulator setup. GC analysis showed that gas composition consisted of C_3H_6, C_3H_8, C_2H_4, C_2H_6, CH_4, CO_2 and CO in concentrations that differ depending on the raw material and process conditions. HHV and elemental analysis of biocrude showed an increase that exceeded 50% compared to feedstock. A pilot-scale construction consisting of two semi-batch reactors with a total of 12 L volume reactor is currently built and proof of concept experiments have been successfully operated. The design of the reactors array includes parabolic trough collectors in order for the heating to be provided by concentrated solar radiation.

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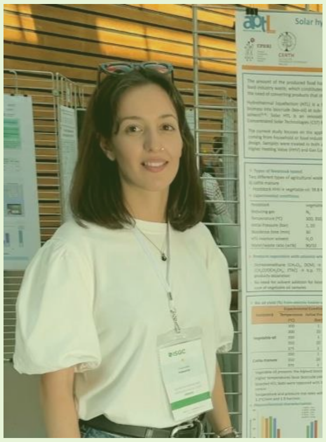

Short biography: I have been working in CERTH since 2019 when I graduated from the Chemical Engineering Department of the Aristotle University of Thessaloniki. I have been involved with the experimental development of hydrothermal liquefaction (HTL) and physicochemical characterization of feedstock and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

From sources of oligosaccharides to bioactive glycophenolics with high potential in therapy

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Abstract:

Our research group uses natural sources of oligosaccharides or glycosides to prepare various bioactive glycophenolics under catalysis commercial glycosidases (including their less known side activities) or plant glycosidases. Using this approach, we have prepared for example salidroside and its α- and β- galactoanalogues, also fructofuranosides of tyrosol and hydroxytyrosol, tyrosol rutinoside and various alkyl rutinosides, tyrosol and hydroxytyrosol β-mannopyranoside. Substrates for this biosynthesis can be found in various industrial wastes (e.g., hydroxytyrosol from olive oil production, lactose and other oligosaccharides from food production, mannobiose from coconut flour, etc.). Plant biomass is also important source of enzymes, especially diglycosidases. We are working on isolation and characterisation of rutinosidase from Tartary buckwheat wholegrain seed meal, the same type of enzyme was used from *Sophora japonica* flower buds and we are working on screening and characterisation of acuminosidases, primeverosidases, vicianosidases and β-apiosidases. Our Laboratory has developed procedures for synthesis of specific chromogenic substrates for quantification of such activities and enzymes assays using these substrates. These enzymes are applied in synthesis of structured diglycosides. Purification and characterization of diglycosidases proceeds in cooperation with other departments of our Institute.
Our results have contributed to extension of knowledge about β-apiosidase and its reaction mechanism, occurrence and availability. Research in the field of diglycosidases shows that plant diglycosidases are more regioselective than microbial sources, they prefer primary hydroxyl in transglycosylations, but specificity towards natural glycosides is much higher than synthetic analogues, so determination of natural aglycones is sometimes necessary to evaluate activity in reaction conditions. Results of biological activities of most prepared glycophenolics suggest positive effects in prevention of proliferation, DNA damage and cell viability.

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Pelletization of refuse derived fuel as a pre-treatment process for solid fuel production

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Abstract:

Poor knowledge of the energy potential and quality of waste has been identified as one of the main obstacles to the better use of this waste. The present study aims to study the effect of pelletization on the fuel characteristics of refuse derived fuel (RDF) from municipal solid waste (MSW) produced on a pilot-scale. And to evaluate the suitability of pellets made of 100% RDF as feedstock for thermochemical processes of energy conversion. The RDF was received in September 2021 and stored outdoors, protected by a plastic screen. It was supplied by Braval-Valorização e Tratamento de Resíduos Sólidos, S.A., which is a Portuguese solid waste recovery and treatment company in the Baixo Cávado region. The RDF used contained 32% plastics, 16% tissues, 11% paper/cardboard, and the remaining fraction of unidentified material. A large proportion of plastic waste is present in RDF, indicating inefficient recycling and sorting. Nevertheless, this fraction has a positive effect on RDF, contributing to a lower moisture content and a higher heating value. The results of the physical and chemical characterization of the RDF pellets showed that they had bulky density of 698.8 kg/m^3, mechanical durability of 99.6%, moisture content of 8.3%, ash content of 8.7% on a dry basis, and a higher (HHV) and lower (LHV) heating value of 20.6 MJ/kg and 19.3 MJ/kg on a dry basis, respectively. The thermogravimetric analysis that allowed the pyrolytic behavior of the RDF pellets to be analyzed indicated the presence of mixed plastics in their composition, such as polypropylene, polystyrene, polyethylene, and polyethylene terephthalate, which mainly decomposed between 250-500°C. In general, the RDF pellets obtained present characteristics suitable for solid fuel.

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Short biography: Santa Margarida dos Santos has a degree in Renewable Energy and Environment Engineering from the Instituto Politécnico de Portalegre and Master in Bioenergy from the Faculdade de Ciências e Tecnologia of the Universidade Nova de Lisboa. Has developed research work in Research Fellowships (PoliTechWaste and AmbWTE projects) in waste recovery, bioenergy, and renewable gases through gasification. In terms of publications, she has 2 journal articles, 6 conference papers, 2 posters and 2 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.

Maize crop residues: chemical characterization and biomethane potential

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Abstract:

The actual development of the biomethane sector from agricultural productions in Italy represents an opportunity to consolidate and strengthen EU energy transition objectives, as well as have a positive impact on the entire agricultural sector. The promotion of a sustainable and circular economic model aims to reduce significantly the emissions and has a key role in the near future to limit GHG emissions and to mitigate the constant temperature increase. With a view to the circular economy and environmental sustainability in agriculture, the recovery of maize residues is a strategic issue for the competitiveness of the sector. Maize residues, largely available in the northern Italian area, due to their productivity and biomass quality, could be interesting for energy valorization. Within the regional project 'Mais100%' project (http://mais100.it), different innovative harvesting solutions were tested for maize stalks (after mash or grain harvest) with the aim of identify the best ones in terms of production/economic efficiency and biomass quality.
The analysis of the compositional characteristics carried out on two harvest years (2020-2021) revealed a wide variability of the parameters. Total solids content (TS), measured between 23 to 45%, depended both on the state of maturity of the plants and on the time elapsed between the harvest of the main product (whole or grain mash) and of the residues left on the field. The ash showed a wide range of values, between 6 to 12 % on TS. Higher values were found in samples from the harvesting site with a shredder-and-rower equipment, which evidently increased the contamination with soil. Overall, the composition of maize residues is rather similar to sorghum or autumn-winter cereal as the Triticale, but the higher lignocellulosic component (cellulose, hemicellulose, lignin) is affected by slower degradation. The difference to whole silage is evident in the starch content, which is almost reduced by about tenfold in the residues compared to the grains. The values of the Biochemical Methane Potential (BMP), achieved through batch anaerobic digestion laboratory tests, varied depending on the quality of the harvested residues. Considering a standardized dry matter of 32-33%, the methanogenic potential of the maize stalks averages 90-95 Nm^3CH_4/t. The degradability of organic matter obtained in BMP test was generally below 70% in fresh material and reached values close to 80% in silage materials, with the exception of the more 'mature' plant residues, which are drier and more lignified. Considering the average BMP value obtained, the electrical energy producible from the analyzed maize stalk samples was 350-380 kWh_{el}/t; moreover, the GHG savings due to the utilization of such residues for energy production would be equal to 6,14 gCO_2eq/t (19,9 gCO_2eq /MJ). These results are encouraging and promise the use of maize residues for biomethane production, allowing to apply the basic principles of circular economy such as valorize residual matter and nutrients, produce renewable energy and advanced biofuels.

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

Circular economy: turning industrial effluents into resources using microbiology

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Abstract:

Selenium (Se) and bacteria are intimately linked in a complex interplay (Staicu and Barton, 2021). Selenium serves both essential and energy generation functions for bacterial metabolism, in addition to behaving as a powerful toxicant under certain conditions. Conversely, bacteria are involved in all valence state transformations of Se, thus acting as a key vehicle for the cycling of this element in nature. With the advent of the Industrial Revolution, the natural cycles of numerous chemical elements, including Se, have been altered. Nowadays, an important share of global energy is generated by coal combustion. During coal combustion in power plants, Se enters the wet Flue Gas Desulfurization (FGD) scrubber, where an important share is concentrated in the FGD wastewater (Staicu et al., 2017). FGD effluents can be treated by bioremediation, using bacterial metabolism to convert soluble and toxic forms of Se into solid, elemental Se, Se^0. These redox transformations can be harnessed to clean-up industrial pollution, and additionally coupled with the recovery of Se as biogenic Se^0 (nano)particles and biogas (Cordoba and Staicu, 2018). Various bioreactors have been tested for FGD treatment and some are commercially available. Here we explore the coupling of the FGD treatment and resource recovery using an integrated system, in the framework of circular economy. A next step would be to mix Se-rich industrial effluents low in organic matter with high-strength organic-rich effluents such as those generated by breweries. This approach not only reduces the burden of Se and organic pollution (e.g. eutrophication) on aquatic ecosystems, but also provides a way to recover valuable resources (Se is an important raw material for many industries; biogas is a renewable source of energy), thus generating profit and offsetting the treatment costs.

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Short biography: I am principal investigator (PI) at Department of Bacterial Genetics, Faculty of Biology, University of Warsaw (Poland), working on Microbial Biotechnology and Geomicrobiology. I am particularly interested in the interaction of bacteria with metals (biomineralization, detoxification and respiration) and the production of (bio)minerals having high-industrial value (e.g. Se^0, PbS, BaSO4). Another research directions we are pursuing is the bioremediation of metal-rich industrial effluents such as those generated by the mining industry and the chemical recovery of barite ($BaSO_4$), a Critical Raw Material (CRM) for the European Union. More info about our research interests and output can be found at https://staiculab.com/

Marine biomass pyrolysis over metal impregnated biochar based catalyst

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Abstract:

The Baltic Sea endures eutrophication processes from the discharge of nutrients. Consequently, this process accelerates the growth of micro and macroalgae, oxygen consumption and forming the biomass wastes on the shores. In case that biomass is not collecting, it significantly increases the eutrophication process. This study aims to investigate a newly prepared seaweed biochar-based metallized catalyst and its application for a catalytic pyrolysis. The main reasons for the use of biochar as a substrate for catalyst is a low price, the functional group tailoring and the large surface area. In addition, it has a stable structure and exhibits mechanical and thermal stability. In this study, experiments on the degradation of seaweeds over metal (Fe, Cu) impregnated biochar based catalyst and commercial ZSM-5 catalysts were carried out. The pyrolysis process was carried out in a laboratory-scale pyrolysis reactor at the temperature of 700 °C with a feedstock load of 250 g. The GC/MS analysis of the liquid products revealed, that catalyst significantly increase the formation of liquid products up to 42.12 wt.% with the seaweed sample. The most common compounds in the seaweed liquid products are variously substituted phenolic (19.47%) and aromatic (21.47%) compounds, some acids (11.12%), and alcohols (7.46%). Moreover, copper-impregnated catalyst increased the amount of toluene in one of the batches up to 84.24% showing potential for this solvent recovery. Based on the investigated results, char-based metallised catalyst significantly increased amounts of valuable products. It is clear that the pyrolysis process is a feasible and promising process for the marine biomass wastes utilisation, obtaining additional higher-added value and energy products, contributing to the creation of a circular economy.

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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.

Thermodynamic feasibility analysis of *E. coli* metabolic model

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Abstract:

Increasing greenhouse gas emissions lead to global warming and climate change, therefore necessitate developing reliable and economical processes/technologies that produce less carbon dioxide (CO_2) or use CO_2 effectively. The most suitable are bio-based processes due to their lower greenhouse gas emissions compared to petrochemical processes, potential for utilizing renewable resources, saving energy and effectiveness in fighting climate change. However, development of innovative processes requires a good understanding of the organism. It is advantageous that many methods in metabolic engineering and system biology have been developed and applied for *Escherichia coli*, one of the most widely known industrial microorganisms. We focus on time-dependent analysis of thermodynamic constraints on metabolic networks. This approach relies on thermodynamic feasibility analysis under dynamic conditions with time-dependent Gibbs energy calculations. Here, I would like to focus on calculating the Gibbs energies of metabolic reactions in the stoichiometric metabolic model of *E. coli* using time-dependent uptake/release rates and metabolome data in the presence of three different substrates - glucose, pyruvate, succinate and on determination of thermodynamic bottlenecks in the metabolic model. On the long-term it is aimed to reveal whether there is an upper limit on the cellular Gibbs energy dissipation rate to be calculated from the dynamic metabolome data using *E. coli* model and to investigate CO_2 fixation capacity of *E. coli* with the method to be developed. Here, preliminary results will be discussed of which the project is directly related to "European Green Deal", and by predicting contribution of *E. coli* to CO_2 fixation, using such pathways in production of chemicals will contribute to the reduction of carbon emissions and climate change impacts, yielding in sustainable usage of energy.

Details of presenting author

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Short biography: I studied chemical engineering during BSc and MSc at Bogazici University in 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 professor at Department of Genetics and Bioengineering at Istanbul Bilgi University.

The CERTH bioenergy facilities

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Abstract:

The current presentation begins with a short introduction of CERTH and indicative quantitative figures, then continues with the presentation of the research areas of CPERI (Chemical Process and Energy Resources Institute) and, finally, aims to focus on the bioenergy facilities of CERTH. As some of the core activities of CPERI/CERTH include Clean Energy and Circular Economy, the development of novel technologies in the field of zero/low-carbon fuels and chemicals production is of paramount importance. Indicative relative infrastructure in the portfolio of CERTH consists of demo and pilot plant units, both in the main campus of CERTH as well as in other areas of the regions of Central and Western Macedonia. Namely, the relative infrastructure includes a lab-scale biomass pyrolysis unit, large scale biomass power plants, a mobile plant for digestate processing for the obtainment of nutrients and clean water as well as the largest mobile solar hydrothermal liquefaction pilot plant. Lab-scale autoclave reactors for biomass treatment and conversion into biofuels are also available, integrating concentrated solar power (CSP) to cover the thermal needs of the process. CERTH has also developed the first interactive platform in Greece for mobilizing biomass resources, which is a smartphone application tool where farmers automatically upload their available biomass in a database, whereas collectors/transporters organize the logistics part aiming at its distribution to end users. Last but not least, CERTH hosts laboratories for biomass (and the respective products) physicochemical characterization focusing in particular on bioenergy applications.

Details of presenting author

Name: Dr. **Nikolaos I. Tsongidis**
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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 13 peer-reviewed publications *(h-index: 8)* with over 30 attendances in international conferences and workshops.

Investigating the role of clean biofuels in meeting transport decarbonization goals: An economic analysis

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Abstract:

As the demand for electric vehicles (EVs) rises, the limitations of charging infrastructure and range anxiety make a full transition to EVs highly unlikely. Clean biofuels, including biogasoline, biodiesel, and renewable diesel, provide an alternative that can curb emissions and benefit from existing infrastructure. However, it is unclear how this affects optimal decisions due to constraints on biofuel production. This study uses a two-stage approach to investigate consumer choices and investment decisions considering the availability of biofuels. Firstly, a theoretical model is set up to understand how decisions are shaped, and secondly, optimal solutions are characterized by calibrating model parameters using available data. This study is the first of its kind to examine the impact of clean biofuels on EV demand and investment in charging infrastructure. Although ongoing, the study offers potential policy implications for consumers and policymakers alike. For consumers, the availability of a clean alternative to EVs means that it may be more economical to avoid switching to EVs. For policymakers, the availability of biofuels provides an opportunity to design targeted policies, such as tax incentives, to promote the use of clean fuels and optimize investments in charging infrastructure, leading to improved economic welfare. The study is also informative for future policy decisions related to car choices and alternative fuels. Ultimately, this study offers valuable insights into the potential benefits of alternative fuels, such as biofuels, for curbing emissions and improving environmental sustainability.

Details of presenting author

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

Upgrading pasta waste through lactic acid fermentation

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Abstract:

During its production process, every kilogram of pasta manufactured generates about 23 g of pasta wastes (PW). Considering the global pasta production, there are about 376 kilotonnes of PW produced every year. In this work, PW were characterised and used as the substrate in lactic acid (LA) fermentations. Enzymatic hydrolysis of 200 g/L of PW allowed for the release of sugars (s) with a yield 0.81 g s/g dryPW. After the screening of several *B. coagulans,* the strain A559 was selected for experiments at the lab and pilot scales. Two fermentation modes were tested during lab scale experiments namely, simultaneous saccharification and fermentation and sequential hydrolysis and fermentation with the latter showing higher yields. The process was scaled up to 50 L where a LA concentration of 47.7 g/L and yield of 0.67 g LA/g dryPW were achieved.
Furthermore, attempts were made to improve the economics of the process by replacing commercial enzymes required for starch hydrolysis in PW with crude enzymes also produced from waste. Enzyme synthesis was achieved by solid-state fermentation (SsF) of wheat bran by *Aspergillus awamori* or *Aspergillus oryzae* at different moisture contents. Subsequently, the hydrolysate was fermented again with *Bacillus coagulans* A559 to LA, yielding 52 g/L and 49 g/L with and without yeast extract, respectively. Remarkably, a higher LA yield was obtained when enzymes produced by SsF were added (0.80 g LA/g glucose) compared to the procedure using commercial enzymes. Moreover, the productivities of the two processes were similar (about 3.9 $g \cdot L^{-1} \cdot h^{-1}$), which underlines that yeast extract is not necessary when SsF-produced enzymes are used.

Details of presenting author

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Short biography: Dr. Joachim Venus, Senior Scientist “Industrial Biotechnology” holds a diploma on Biotechnology and a PhD on Bioengineering. He is head of the research group bioconversion and scientific manager of a pilot facility at the ATB. His work emphasized on the development and scale-up of continuous mode fermentation processes for the production of fine & basic chemicals - in particular organic acids - from biogenic resources. He is in charge of numerous (inter-)national research projects being carried out in the multi-functional pilot plant for the development and optimization of bioprocesses based on biomass and residues.

Biomethane potential of lignocellulose-rich effluents during anaerobic treatment

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Abstract:

In this study, biomethane potential through anaerobic treatment of lignocellulose-rich effluents from paper industries is evaluated based on the findings of different lab-scale anaerobic reactors operated at different conditions. In this context, Turkish paper and cardboard products industry holds about 2 percent of the world's paper production capacity, with more than 5 million tons in the last decade. On the other hand, paper products consumption was more than 6 million tons, which makes this sector as the 16th major consumer goods market. However, high water demand during paper production stage makes this industrial sector as the third largest wastewater producer. Many organic and inorganic pollutants found in paper industry wastewater can cause environmental problems such as dissolved oxygen depletion, toxicity, colour and turbidity if they are discharged into the receiving waters without subjected to any treatment. Lignocellulose-rich effluents with high organic contents might be benefitted as different renewable energy sources (e.g., biogas, biodiesel, bioethanol, etc.) with appropriate treatment technologies such as anaerobic reactors. However, degradation of the hemicellulose and cellulose contents (i.e., ~60%) of paper wastes by the microorganisms is not easy. Cellulose and starch-degrading bacteria have been reported to belong to the phyla *Bacteroidetes, Fibrobacteres, Spirochaetes*, and *Thermotogae,* whereas *Euryarchaeota* under archaea domain consist of the methanogens crucial for methane production. Although the competition between sulfate reducers and methane producers for the available carbon and hydrogen sources leads to stoichiometrically reduced biogas; anaerobic biotechnology plays important role in the treatment of industrial wastewaters especially the effluents from paper and paper facilities for renewable energy generation. On the other hand, lignocellulosic biomass is an abundant, exceptionally economical feedstock for the production of more value-added products such as low price xylose like chemicals, bio-fibres, ruminant feed, bio-pulp, or even for enzyme production. Preliminary studies reported that high-rate anaerobic reactors like upflow anaerobic sludge bed (UASB) reactors indicated effective treatment and satisfactory biomethane production while treating lignocellulosic wastewaters. Accordingly, cumulative biogas production in an UASB reactor yielded from 160 to 380 L per 1 kg of total chemical oxygen demand (COD) removed, which corresponded to approximately 25 kWh total energy (electricity+heat) generation per 1 m^3 of wastewater treated at mesophilic (35 °C) condition. Besides, influent and effluent total COD concentrations were 26129±2482 and 638±117 mg/L, respectively, with more than 95% removal. On the other hand, in a batch anaerobic study; total COD decreased from about 10000 to 580 mg/L with a removal of 94% at 70-d incubation period which corresponded to a cumulative methane yield of 370 L per kg of total COD removed at mesophilic (35 °C) condition whereas net methane yield was 490 L per 1 kg of volatile solids (VS) fed at thermophilic (55 °C) condition. Hence all findings revealed considerable biomethane

potential of paper industry wastes through anaerobic treatment with significant contribution to sustainable and feasible waste management and energy recovery.

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Short biography: She received her BSc in Environmental Engineering Department from Istanbul Technical University and her MSc in Environmental Sciences from Bogazici University, İstanbul, Türkiye. She completed her PhD at Environmental Engineering Department in Istanbul Technical University. During her PhD study, she visited Vanderbilt University in USA and Munich Technical University in Germany. Her main topics of interest are design of anaerobic systems and microbial identification; biogas production and energy recovery from organic wastes; sludge treatment, management, and disposal. She is still working as a professor at Istanbul Technical University Environmental Engineering Department.

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