Università degli Studi di Torino

NIS — NANOMATERIALS FOR INDUSTRY AND SUSTAINABILITY

NIS Interdepartmental Center – www.nis.unito.it

International Workshop & NIS colloquium

Valorisation of solid and gas residues of thermochemically processed biomass waste

November 30th, 2023
Aula 14 - Via Quarello 15/a, Torino

Attendance is free but registration is required:
NIS Colloquium UniTO (by 28/11/2023)
For any further information please write to: erikamichela.dematteis@unito.it

10.30-10.45
Welcome coffee

10.45-11.00
Gabriele Ricchiardi - *Director of NIS Interdepartmental Centre - Università di Torino*
Marcello Baricco - *President of NIS Interdepartmental Centre - Università di Torino*
Welcome address

Morning session

Chair: **Marcello Baricco**

11.00-11.30
Javier Abrego
Universidad Zaragoza, Zaragoza (Spain)
An overview of thermochemical processes for waste biomass valorisation

11.30-12.00
Francesca Valetti
Università di Torino, Department of Life Sciences and Systems Biology, Torino (Italy)
Biohydrogen production and exploitation: greener than green

12.00-12.30
Fernando Bimbela
INAMAT^2 - Institute for Advanced Materials and Mathematics - Universidad Pública de Navarra, Pamplona (Spain)
An overview of research activities at UPNA regarding CO_2 hydrogenation, solar and e-fuels production and biogas reforming

12.30-13.00
Silvia Tabasso, Emanuela Calcio Gaudino
Università di Torino, Department of Pharmacy, Torino (Italy)
Enabling technologies for biomass valorisation

13.00-14.00
Light Lunch

Afternoon session

Chair**: Mauro Sgroi**

14.00-14.30
Dario Alvira Dobón
Universidad Zaragoza, Zaragoza (Spain)
Vine shoot-derived hard carbons as promising anodes for sodium-ion batteries

14.30-15.00
Giacomo Magnani
Università di Parma, Department of Physics, Parma (Italy)
Valorisation of biowaste for energy applications

15.00-15.30
Linda Pastero
Università di Torino, Department of Earth Science, Torino (Italy)
Carbon mineralization: a valid alternative for a solid-state safe carbon reservoir

15.30-16.00
Erika Michela Dematteis
Università di Torino, Department of Chemistry, Torino (Italy)
Valorisation of hydrogen by using metal hydrides: outlook and closing remarks

16.00
Closing of the workshop

Full program available at:		Online connection available at:	

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An overview of thermochemical processes for waste biomass valorisation

Biomass residues from agriculture and forestry are almost everywhere. Historically, they have been combusted for energy production. Nevertheless, biomass is also the only widely available source for renewable carbon; thus, in a decarbonized, circular economy context, most of this resource should be better directed towards the production of chemicals and fuels that cannot be produced otherwise (the biorefinery concept). Thermochemical processes such as pyrolysis and gasification are being intensely researched for these means. This talk will summarize the basics of these technology alternatives, including routes for hydrogen production which are fully compatible with the concept of biorefinery.
Besides, fight against climate changes is an urgent effort that requires not only carbon emissions reduction, but also carbon dioxide removal from the atmosphere. Biomass is carbon naturally stored by plants. In this context, thermochemical biomass transformations offer a double opportunity: obtaining valuable, renewable products and fuels while capturing a significant part of the biomass original carbon during the process.

Javier Ábrego is PhD in Chemical Engineering and assistant professor at the Chemical Engineering and Environmental Technology Department, University of Zaragoza. He belongs to the Thermochemical Processes Group at the Aragón Institute of Engineering Research. He has held postdoc positions at the Spanish National Research Council and the University of Hawaii, USA. His research interests are focused mostly on the development of thermochemical processes for waste biomass valorisation.

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Biohydrogen Production and Exploitation: Greener than Green

Francesca Valetti

Department of Life Sciences and Systems Biology, University of Torino, Italy
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Bio-hydrogen production via dark fermentation of low value waste is a simple mean (and a win-win strategy) of recovering energy, maximizing the harvesting of reducing equivalents to produce the cleanest fuel amongst renewables.
Since 2008, we have studied hydrogen production from several types of waste and investigated the main relevant biocatalysts for hydrogen production, namely [FeFe]-hydrogenases expressed in Clostridia, given their very high turnover rates and peculiar stability for applicative purposes.
An overview of the bio-based hydrogen production results and of biocatalysts potential for both hydrogen production and technological exploitation is given from a biochemist's perspective.

Francesca Valetti: Associate Professor of Biochemistry, MSc in Biology and PhD in Protein Chemistry at the University of Torino. Post-doc at Imperial College, London and, since then, redox enzymes addicted.

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chimica
2023 - 2027 DIPARTIMENTO DI ECCELLENZA
Ministero dell'Università e della Ricerca

An overview of research activities at UPNA regarding CO_2 hydrogenation, solar and e-fuels production and biogas reforming

Fernando Bimbela

Senior Lecturer and Secretary of the INAMAT^2, Chemical Reactors and Processes for Valorization of Renewable Resources (QUIPROVAL), Institute for Advanced Materials and Mathematics (INAMAT^2), Universidad Pública de Navarra (UPNA), Pamplona (Spain)

CO_2 capture and utilization (CCU) technologies rely on the use of CO_2 as a source of carbon for obtaining various hydrocarbons having industrial or fuel applications. Renewable hydrogen-derived synthetic fuels based on carbon-neutral CO_2 (or e-fuels) can be regarded as drop-in fuels that could contribute to, on the one hand, meet present EU's ambitious targets and, on the other hand, to valorise CO_2 from different industrial effluents. The use of solar energy for developing photocatalytic and photo-thermocatalytic conversion of CO2 to fuels (i.e., solar fuels) may also be viable using certain technologies (e.g. structured catalytic microreactors). Other possibility is to develop direct catalytic methanation of CO_2-containing biogenic streams, as biogas, or to increase biomethane production from biogas upgrading after CO_2 separation. To that end, other alternatives can be considered for biogas upgrading including syngas production by combined reforming processes.

The general objective of this talk is to provide an overview of the research activities conducted at UPNA's QUIPROVAL group on valorisation of CO_2-rich effluents via CO_2 hydrogenation and/or combined reforming by photo-thermo and thermocatalytic routes.

Fernando Bimbela (Msc. in Chemical Engineering, Univ. of Zaragoza (UNIZAR), Spain) received his PhD Degree in Chemical and Environmental Engineering in the same University in 2010. From 2004 to 2014 he was a member of the Thermochemical Processes Group (GPT) in the Aragon Institute for Engineering Research (I3A) of UNIZAR. He is currently a senior lecturer in the Public University of Navarra (UPNA, Pamplona, Spain) and a research member of the Chemical Reactors and Processes for the Valorisation of Renewable Resources group (QuiProVal), led by Prof. Dr. Luis M. Gandía, at UPNA's Institute for Advanced Materials and Mathematics (InaMat^2). Since March 2019 he has also taken duties as Secretary of the InaMat^2.

According to Scopus metrics (https://www.scopus.com/authid/detail.uri?authorId=16229431000), his H-index is currently 18 and he has co-authored >40 peer-review articles (28 included in the Clarivate's JCR Q1 of their category), having received >1200 citations so far. To date, he has already supervised 5 PhD theses, and several other Master and Diploma theses. He has also been and the main researcher for various research projects at a regional and national level, as well as having participated in more than 20 research projects, both at national and international levels. The research activity developed to date comprises various disciplines, from catalysis for syngas and energy carriers through waste valorisation of residues from different sources, thermochemical conversion of biomass and lignin depolymerization, among other topics.

UNITA universitas montium · GPT Thermochemical Processes Group · CREG · I3A · Instituto Universitario de Investigación en Ingeniería de Aragón Universidad Zaragoza · 20 Aniversario 2002-2022 20 años investigando juntos · 1542 Universidad Zaragoza

Enabling technologies for biomass valorisation

Bio-waste valorisation has been one of the hottest research topics worldwide over the last decade. Following the biorefinery concept, the main goals have been the search for inexpensive renewable resources for the production of chemicals, materials and energy, the transformation of bio-waste into useful by-products and the development of new technologies for process intensification to make all these conversions economically profitable. Bio-waste is generally a negative-cost feedstock for the potential production of high value-added chemicals and bioenergy. The present communication has the aim of describing non-conventional energy sources such as microwaves and cavitation for the conversion of biomass into fine chemicals.

Emanuela Calcio Gaudino received her PhD in 2011 working on ‘‘Innovative eco-friendly strategies for process intensification in organic synthesis’’. She is currently an Associate Professor in Organic Chemistry at the Department of Drug Science and Technology (University of Turin). Nowadays, she is involved in the study of biomass wastes as a renewable source of chemicals; in particular, she is working on the conversion of biomass to chemicals under non-conventional methods.

Silvia Tabasso completed her PhD in Chemistry in 2007 at the University of Turin, working on the characterization and synthesis of natural products. She is currently Associate professor in Industrial Chemistry at the Department of Drug Science and Technology (University of Turin). Nowadays, she is working on the conversion of biomass wastes into high added-value products through sustainable processes (green solvents, heterogeneous catalysis, enabling technologies).

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Vine shoot-derived hard carbons as promising anodes for sodium-ion batteries

D. Alvira[1], D. Antoran[1], V. Sebastian[2], JJ. Manya[1]

[1]Aragón Institute for Engineering Research (I3A), Thermochemical Processes Group, University of Zaragoza, Escuela Politécnica Superior, Crta. Cuarte s/n, 22071 Huesca, Spain

[2]Instituto de Nanociencia y Materiales de Aragón (INMA), CSIC-Universidad de Zaragoza, Zaragoza, Spain

Sodium-ion batteries (SIBs) are one of the most promising candidates to lead the next generation of large-scale electrochemical energy storage systems required to support the grid integration of intermittent renewable sources. However, the implementation of this technology is contingent upon the development of new high-performance anodes, since sodium ions cannot be intercalated in graphite anodes, which is the common anode material in lithium-ion batteries (LIBs). Among other intercalation materials, hard carbons (HCs) are the most promising candidates since they can storage Na^+ in their surface functionalities, defects, and pseudographitic domains. Moreover, HCs derived from biomass waste resources are in the spotlight due to superior reversible capacities and environmental and cost-effectiveness considerations. Herein, hard carbons were synthesized through the thermal conversion of vine shoots, a biowaste from wine-growing regions. Various synthesis pathways were investigated to enhance the electrochemical properties of HCs, encompassing both direct pyrolysis and hydrothermal carbonization techniques. In the latter case, beyond water, alternative solvents such as pig manure slurry and aqueous solutions of acids (H_2SO_4, H_3PO_4, HCl, and HNO_3) were explored to promote heteroatom doping and catalyze hydrolysis reactions. Finally, we are also engaged in developing advanced materials by incorporating active redox substances within the carbonaceous matrix (e.g., MoS_2). This presentation will provide an overarching perspective on the achieved outcomes and how distinct synthesis methods can yield diverse materials from a single biomass source.

Darío Alvira (Alcolea de Cinca, Spain). Bachelor's degree in Environmental Sciences, Master's degree in Chemical Engineering and currently in the final-year of the Chemical and Environmental Engineering PhD studies at the University of Zaragoza. https://orcid.org/0000-0002-5526-3962.

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Valorisation of biowaste for energy applications

Magnani G[1,2], Rinaldi A[1], Ahmad N[1], Scaravonati S[1], Morenghi A[1,2], Sidoli M[1], Girella A[3], Milanese C[3], Riccò M[1,2], Pontiroli D[1,2]

[1]*Mathematical, Physical and Computer Sciences Department, University of Parma, Parma, Italy*
[2]*National Interuniversity Consortium of Materials Science and Technology (INSTM), Florence, Italy*
[3]*Pavia Hydrogen Lab, C.S.G.I. - Department of Chemistry, Physical Chemistry Division, University of Pavia, Pavia, Italy*

Activated carbons derived from biowaste materials (Activated Biochars) have gained significant attention in recent years as promising candidates for energy storage applications, including supercapacitors, batteries, and hydrogen storage. This sustainable approach not only mitigates environmental concerns associated with waste disposal, but also offers economically viable energy storage solutions. In this study, we explore the preparation methods, structural properties, and electrochemical performance of waste-derived activated carbons for energy storage. Various waste sources such as biomass residues, industrial byproducts and discarded materials are considered as potential precursors for carbonization and activation. The resulting activated carbons exhibit promising properties, including high specific surface area, pore volume, and pore size distribution, which are crucial for energy storage applications. In supercapacitors, these materials can play a key role as electrodes thanks to their outstanding properties of high-power density, fast charge/discharge cycles, cycling stability and a longer life of devices respect to batteries. Activated biochars are also investigated as anode materials in batteries, showing promising performance in terms of capacity, cycle life, and safety. Moreover, these materials are evaluated for hydrogen storage, benefiting from their tailored porosity and surface chemistry. Overall, this research provides insights into the potential of these innovative carbon-based materials as sustainable and cost-effective materials for energy storage applications, fostering a more environmentally friendly and economically viable energy landscape, trying to fit also into a green economy context and to meet sustainability requirements.

Giacomo Magnani is a Research Associate (S.S.D FIS/03), Department of Mathematical, Physical and Computer Sciences, University of Parma, Parma (Italy). Teaching: APPLICAZIONI DELLA SCIENZA DEI MATERIALI, Laurea Triennale in Scienza dei Materiali. From 2017 – 2021: Post-Doc activities at the Carbon Nanostructures laboratory of the Department of Mathematical, Physical and Computer Sciences, University of Parma, Parma (Italy), on three different projects: "Hydrogen accumulation in carbon nanostructures"; "Preparation and study of new composite materials based on carbon nanostructures"; "Gaining health and energy from Lombard agrifood waste (GHELF)". From 2015 – Today: Teaching support in "Carbon-based nanostructured materials (M.Sc. Course), at Department of Mathematical, Physical and Computer Sciences (University of Parma), Parma, Italy. In 2017: Ph.D. in Materials Science and Technology (XXIX cycle), Department of Physics and Earth Sciences, Parma University. Thesis title: "Carbon nanostructures for hydrogen storage".

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Carbon mineralization: a valid alternative for a solid-state safe carbon reservoir

The concentration of carbon dioxide in the atmosphere is steadily increasing due to human activities, which are adding to natural outputs. To maintain concentration levels below the no-return threshold, it is necessary to consider many synergistic capture methods in conjunction with reducing emissions. Mineralization is a permanent carbon capture method that could be a reliable companion to other methods. It allows the storage of CO2 in solid-state, safe, and stable crystal lattices via weathering-like reactions. We can engineer high-performing carbon capture methods by taking advantage of the tenets of rock weathering. Furthermore, we can couple carbon capture and wastewater or critical metals recovery in a single-step mineralization process. The flexibility and trustworthiness of mineralization methods make them a valid support for environmental care.

Linda Pastero is Associate Professor of Mineralogy at the Department of Earth Sciences of the University of Torino. She is a member of the Italian Association of Crystallography (AIC) and coordinator of the Crystal Growth section within the association, a member of the International Organization for Crystal Growth (IOCG), and secretary of the European Network of Crystal Growth (ENCG). Her research activity formerly targeted the mineralogical and geochemical characterization of soils (diffractometric analysis of the clay fraction, geochemistry of anthropogenic heavy metals in soils and their interactions with clays), focused then on the study of nucleation and growth mechanisms of crystalline phases of environmental, biomineralogical and industrial interest. Her work is mainly aimed at the comprehension of the nucleation and growth mechanisms of several crystalline phases belonging to the carbonates, phosphates, oxalates, sulfates, and alkali halides groups and at the comprehension of the mechanisms related to the ab-/ad-sorption phenomena of impurities and epitaxial interactions between phases as the fundamental mechanisms to control crystal morphology and structure, mainly aimed at the achievement of functional architectures such as those of biominerals (biomimicry), up to the generation of mixed phases and polymorphism.

Valorisation of hydrogen by using metal hydrides: outlook and closing remarks

Hydrogen is considered as a good energy vector to implement a greener energy future. Furthermore, it could be a precious by-product of recycling process that can be further transformed or collected to generate an added value instead of just burning it to produce process heat.
An overview of the GFI project will be presented, the project aims at developing a unique combination of technologies to efficiently produce, purify and store hydrogen. New innovative production of hydrogen has been investigated, together with its collection and valorisation in recycling processes, such as pyrolysis of biomasses. In fact, starting from several biomass sources, and using various techniques, involving pyrolysis, gasification, reforming, and chemical looping, waste can be recycled, and new chemicals or valuable gases can be produced at high temperature and low pressure, and used in a circular economy approach to make them profitable.
A special focus will be linked to the combined purification and storage of produced hydrogen in the solid state by an innovative approach using metal hydrides. In fact, commercial materials from SAES getters have been evaluated to promote the hydrogen sorption in Ti/Zr-based alloys.
The unique combination of these technologies can support the development of a hydrogen-based economy, with improved performances in terms of efficiency, cost, and safety, and further push the economic exploitation of biomasses treatment and their valorisation in a circular economy, even for low amount of hydrogen released at low pressure, that can be profitably separated and stored.

Erika Michela Dematteis obtained the title of PhD cum laude in Chemical and Materials Sciences in 2018 at the University of Turin. She is currently a researcher at the Chemistry department of the University of Turin, and she studies metallic and inorganic materials for energy management. Her studies address the development of materials for batteries and for large-scale renewable hydrogen storage, combining theoretical and machine learning approaches and advanced synthesis and characterization methods. In 2022 she was the winner of the Hydrogen Europe Research “Best Researcher of the Year” award.