BOOK OF ABSTRACTS

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3rd GREENERING INTERNATIONAL conference

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Khalifa University

12th - 14th February, Abu Dhabi, UAE

3rd Greenering International Conference

12th-14th February 2025
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Senka Vidovic, University Novi Sad, Faculty of Technology Novi Sad, Serbia
Aleksandra Gavaric, University Novi Sad, Faculty of Technology Novi Sad, Serbia
Natasa Nastic, Khalifa University, Abu Dhabi, UAE and University Novi Sad, Faculty of Technology Novi Sad, Serbia

3rd GREENERING International Conference Co-Editors:
Mirjana Sulejmanović, Siniša Simić, Slađana Krivošija, Isidora Vlaović, all from University of Novi Sad, Faculty of Technology Novi Sad, Serbia

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GENERAL INFORMATION

GREENERING International Conference is an event initiated within the Green Chemical Engineering Network towards upscaling sustainable processes (CA18224) – the GREENERING Action, funded by the European Cooperation in Science and Technology (COST) from Brussels, Belgium. The objective of the GREENERING COST Action was to promote and boost the industrial application of green chemistry and sustainable technologies. The GREENERING International Conference was established in line with those objectives, aiming to gather academics, researchers, and companies in an international forum to promote the application of green chemistry and sustainable technologies in industries, focusing on environmental, innovation, economic, and policy aspects.

The Greenering International Conference covered up to now a wide range of topics, including: Alternative solvents; Green extraction; Waste treatment and valorisation; Bioactive compounds fractionating and formulation using green techniques; Biofuels and Bioenergy; CO_2 capture and Utilization; Green reactions and Catalysis; Biopolymers and advanced biomaterials; Green processes scale-up and industrial applications; Green Policy and Innovations.

The 1st GREENERING International Conference was a two-day event held in February 2021, in Costa da Caparica, Portugal, hosted by DES Solutio, Universidade Nova de Lisboa, Portugal. This two-day event gathered 131 participants from 27 different countries. 35 lectures were given, and 96 posters were presented. The 2nd GREENERING International Conference was a three-day event, organized in March 2023. The event was hosted by the Bioeconomy Institute – BioEcoUVa, from the University of Valladolid in Spain. It gathered 148 participants from 26 countries. 68 speakers gave their talks, while 78 works were presented in poster form.

The 3rd GREENERING International Conference, is a 3-day event, organized from 12th to 14th February 2025, at the Khalifa University in Abu Dhabi, UAE, as the host institution. It gathers 168 participants from 31 countries. 72 talks were given, and 61 scientific works presented in the poster form.

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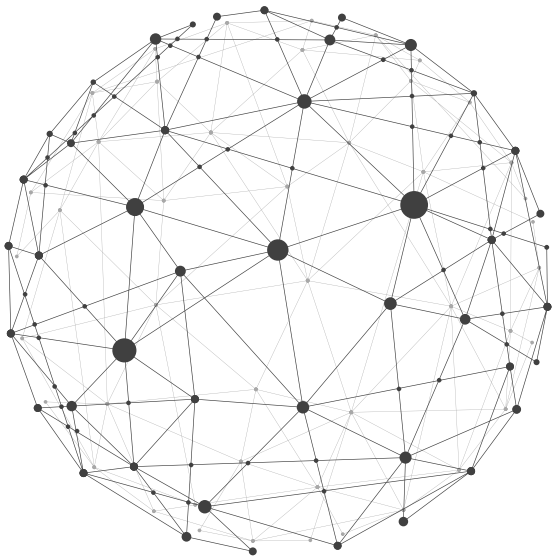

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SCIENTIFIC TOPICS

1. Alternative green solvents and related technologies and processes.
2. Green strategy embedded in biotechnology: biomass, bioenergy, and biobased products.
3. Sustainable practices in bioreneries and waste valorisation as a key priority.
4. Green solutions in development of biopolymers and advanced materials.
5. Advanced CO_2 - capture and utilization.
6. Mechanochemistry and mechanical synthesis for green chemistry: chemical reactions and materials state transformations.
7. Innovative green reactions: synthesis and catalysis.

Plenary speakers

GAS PHASE BIOREFINERIES AS A NOVEL PLATFORM FOR AN INTEGRAL CARBON RECOVERY FROM ORGANIC WASTE

***Muñoz R.*[1,2], *Cantera S.*[1,2], *Garcia-Depraect O.*[1,2], *Bordel S.*[1,2], *Lebrero* [1,2]**

[1]*Institute of Sustainable Processes, University of Valladolid, C/Dr. Mergelina s/n., 47011, Spain.*

[2]*Department of Chemical Engineering and Environmental Technology, School of Industrial Engineerings, C/Dr. Mergelina s/n., 47011, Spain.*

Abstract

The increasing awareness about the need to reduce fossil fuel dependence in order to mitigate climate change, and in particular to decarbonize the transportation sector, has triggered in the past decade the production of biogas and biomethane worldwide. In Europe, this trend has been triggered as a result of the Russian invasion to Ukraine. While membrane separation has gained a major share in the biogas upgrading market over the past 5 years, research in biological methods for CO_2, H_2S and siloxane removal has also attracted significant attention. Thus, hydrogenotrophic biogas upgrading has experienced significant advances, which has resulted in the development of novel process configurations, new insights into process microbiology and significant breakthroughs in technology validation at pilot scale. The expected massive generation of hydrogen from renewable energies will boost this biogas upgrading technology. Similarly, photosynthetic biogas upgrading in algal-bacterial photobioreactors has been optimized and validated at pilot scale and semi-industrial scale, and new photosynthetic biogas upgrading concepts using purple photosynthetic bacteria have been successfully engineered. Electromethanogenesis has also emerged as a promising platform capable of partially removing CO_2 and in-situ generating the required H_2 to fully methanize the remaining CO_2 in biogas. In addition, biogas has been also recently evaluated as a feedstock for the biotechnological production of commodities (biopolymers, proteins, etc.) and high-added value products (i.e ectoine), which open-up new opportunities for biogas valorization. The main limitation of this novel biorefining concept relies on the poor aqueous solubility of methane, which requires the validatio of high performance gas-phase bioreactors. The non-energetic valorization of biogas has been validated at lab scale and is currently under validation in the European Projects CHEERS, CIRCULAR BIOCARBON, and MANUREFINERY. Finally, the solid fraction of digestate can be converted via gasification into CO_2, CO and H_2, which can be further biotransformed into CH_4, ethanol or acetic acid under anaerobic conditions. The latter can be bioconverted into butyric acid, butanol, caproic acid or hexanol via chain elongation under anaerobic conditions.

Keywords: Biogas, syngas, gas-liquid mass transfer,

Corresponding author email: raul.munoz.torre@uva.es

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GREEN SOLVENTS FOR WASTEWATER TREATMENT: FUNDAMENTALS, APPLICATIONS, AND CHALLENGES

Nashef E.

Khalifa University of Science and Technology, 127788, Abu Dhabi, United Arab Emirates

Abstract

As established by the UN development plan, there is a need for more sustainable chemistry that looks after the environmental impact and sustainability of the methods employed. The new environmental policies and legislations for 2010–2050 in many countries call for a drastic reduction in solvents from non-renewable resources. Although highly effective in many applications, harmful volatile organic compounds use must decrease. High toxicity, flammability, and non-biodegradability have exerted an intolerable impact on the environment via unsustainable emissions. A renewed understanding of eco-friendly principles is moving the industrial sector toward a shift in using less harmful solvents as a main strategy to improve manufacturing. The most promising solvents are supercritical fluids, ionic liquids (ILs), and deep eutectic solvents (DESs).

Deep eutectic solvents are mixtures of two or more compounds with strong interaction forces causing a significant decrease in the melting point of the mixture larger than that of an ideal mixture. Based on the appropriate choice of their constituents, DESs have many advantageous characteristics: very low vapor pressure, biodegradability, non-toxicity, non-flammability, simple preparation methods, etc. DESs have been tested for many applications in the laboratory, including extraction, adsorption, electrochemical processes, drug delivery, wastewater, and many others.

In the present work, we will give a brief introduction about DESs, preparation, different types, properties, and characterization methods. A thorough and critical review of the applications of DESs in wastewater treatment, as reported in the literature, will be presented. Water scarcity has led to heavy reliance on desalination worldwide, particularly in the Arabian Gulf region, including the UAE, resulting in adverse environmental impacts and significant energy consumption. Wastewater treatment can help reduce freshwater consumption and limit contaminant disposal. Still, conventional treatment methods are not efficient enough to remove some emerging contaminants, such as poly- and perfluoroalkyl substances, pharmaceuticals, microplastics, etc. In addition, different methods used to predict the properties of DESs will be discussed. Finally, recommendations for successfully implementing DESs in the industry will be addressed.

Keywords: Green Solvents, Deep Eutectic Solvents, Wastewater Treatment, Environment, Sustainability.

Corresponding author email: enas.nashef@ku.ac.ae

Acknowledgments: Khalifa University of Science and Technology

AN OVERVIEW OF SUPERCRITICAL FLUIDS APPLICATIONS

***Seaudeau-Pirouley K.*[1], *Sarrade S.*[1,2], *Joly A.*[1], *Christian Guizard*[1]**

[1]*Innovation Fluides Supercritiques, IFS, Bâtiment INEED , 1 rue Marc Seguin Alixan, 26300, France*
[2]*Commissariat aux Energies Alternatives et à l'Energie Nucléaire (CEA), Saclay, Paris, France*

Abstract

In recent years, the growing interest in environmental issues has allowed the emergence of innovative solutions firmly engaged in sustainable development. Supercritical fluids (SCFs) are a remarkable example of such processes.
Supercritical Fluid Innovation (IFS), a French non-profit organization established in 2006, fosters the adoption of supercritical fluid processes by connecting private and public laboratories. IFS supports industries in testing and implementing this technology. In this lecture, we will share our almost 20 years' experience and discuss future supercritical fluid applications based on emerging R&D trends, highlighting the potential of these processes for innovation and industrial development.

We will first discuss the developments observed in R&D projects, including examples such as sterilization driven by evolving regulations - waste management area where sc. CO_2 is tested on end-of-life waste containing value-added products (WEEE) or valorisation of agri waste materials
- process innovation to optimize the energy consumption.

We will then explore advancements from the perspective of equipment manufacturers. There has been a notable increase in the number of manufacturers (due to CBD) and the development of markets such as chromatography, cleaning, and aerogel production. Additionally, significant innovations have emerged to address key industry challenges, including compactness, mobility, user-friendly designs, water management, and high-pressure operations.

We will go on with the supercritical CO_2 market which can be classified as follows: (1) markets with very low volume and high added value such as pharmaceuticals, medical devices, cosmetics;
(2) markets with high volume and lower added value (food products, packaging materials). A first zoom will be made on classification of applications and processes according to volume of autoclave (from 100 L up to 20 000 L) and pressure associated to the autoclave (from 150 bar up to 1 000 bar). Looking toward industrial applications, the ones which are better known for consumers are nutraceuticals and cosmetics. In this sector, industrial companies are looking for new extracts or active ingredients with must be available fast. Furthermore, cosmetics companies are increasingly purchasing laboratory CO_2 extraction pilots and are running their own R&D and for some their own production. For bigger volume, production goes directly to research platforms which have industrial facilities (100 L up to 1000 L).

As a conclusion, the future is promising, as awareness of the benefits of supercritical CO_2 is only beginning to grow and also equipment manufacturers are pushing the market with easier to use equipment.

Keywords: supercritical processes, trends, CO2 extraction, industries

Corresponding author email:k.seaudeau@ifs tech.fr

Invited speakers

UPSCALING PHARMACEUTICALS BY MECHANOCHEMISTRY

Colacino E.

Institut Charles Gerhadt, Université de Montpellier, France

Abstract

Although there have been efforts to reduce the environmental impact of active pharmaceutical ingredient (API) production, the use of organic solvents (responsible for 75% of energy used) is still a critical step in many processes. Solvent-free synthesis by mechanochemistry fulfills several of the 12 Green Chemistry Principles, and it is an effective and more sustainable approach to improve chemical processes and their safety and to access organic molecules or pharmaceutically relevant fragments and functionalities, including APIs.
This presentation highlights case studies illustrating the upscaling of mechanochemical syntheses, both in batch and continuous modes, aimed at the environmentally friendly preparation of pharmaceuticals. It showcases how mechanical processes offer a sustainable and cost-effective pathway, facilitating the transition to a greener industry.

CRITICAL ISSUES AND SUCCESS FACTORS FOR EFFECTIVELY *GREENERING* THE CHEMICAL AND PHARMACEUTICAL INDUSTRIES

Cravotto G.

University of Turin, Department of Drug Science and Technology, Italy

Abstract

In the past three decades, significant progress has been made; however, the transition to greener industrial processes remains a long journey. Many industrial sectors continue to suffer from inefficiencies, largely due to the improper use of energy, materials, and solvents, as well as a lack of modern technologies used in lab scale. For several reasons, the pharmaceutical industry ranks at the top of the list of worst Environmental Factors (E. Factor), producing 25 to 100 kg of waste for every kilogram of product. Pharmaceutical companies remain reluctant to adopt new technologies and new catalysts due to concerns about the costs of validation, retraining staff, and potential disruptions to established processes. Regulatory approval processes are often extensive and require detailed documentation. Modern technologies may involve novel energy sources that complicate the regulatory review and approval timeline. Moreover, the common practice of third-party pharmaceutical manufacturing, where drug production is outsourced to specialized manufacturers, further hinders the shift toward greener processes. This is largely due to short-term contracts, often renewed annually, which discourage long-term investments in sustainable technologies.

Despite these challenges, both the American FDA and the European EMA have shown increasing interest in fostering innovation. Initiatives like the FDA's "Emerging Technology Program" and EMA's "Innovation Task Force" are designed to support the adoption of advanced technologies by providing guidance and early dialogue. A preferential pathway was recently established for the transition from batch to continuous-flow production. Although the adoption of innovative manufacturing protocols and technologies may present both technical and regulatory challenges, this transformation is necessary for both environmental sustainability and enhanced competitiveness.

The effective industrial *greenering* relies heavily on optimizing downstream processes such as extraction, purification, crystallization, and drying, along with wastewater treatment, which is equally critical. Our group has contributed to the development of several greener chemical industrial protocols, with new catalysts, advanced intensification technologies, and improved downstream methods.

Keywords: Enabling technologies; Green transition; Drug synthesis and downstream; Regulatory approval; Continuous-flow production.

THE PURPLE POWER: PURPLE PHOTOTROPHIC BACTERIA FOR RESOURCE RECOVERY FROM ORGANIC WASTE SOURCES

Puyol D.

University Rey Juan Carlos Mostoles, Department of Chemical and Environmental Engineering & Research Institute of Technologies for the Sustainability, Madrid, Spain

Abstract

The current paradigm in the bioeconomy calls for novel, sustainable biorefineries capable of fully recovering resources from organic waste streams, including both solid organic waste and wastewater. Environmental biotechnology plays a pivotal role in this emerging sector, and several biological processes form the core of these biorefineries. Among these, photosynthesis-based systems stand out, leading to what we refer to as photo-biorefinery.

Photo-biorefineries harness specific portions of the solar spectrum to drive photosynthetic microorganisms in the production of valuable chemical commodities. Notably, the near-infrared region is exploited by anoxygenic photosynthetic microorganisms, commonly known as Purple Phototrophic Bacteria (PPB). Owing to their extensive and versatile metabolism, PPB have become key players in photo-biorefinery development.

Their wide range of applications includes both organic waste and wastewater treatment, coupled with the production of high-value commodities such as microbial protein (MP) for food and feed, antioxidative pigments (carotenoids, bacteriochlorophyll), anti-aging agents (coenzyme Q-10), biopolymers (polyhydroxyalkanoates, alginates), plant growth enhancers (5-aminolevulinic acid), and renewable energy vectors (biohydrogen). PPB can also be applied in gas treatment (e.g., syngas conversion, biogas upgrading) and show strong electroactivity, facilitating their use in microbial bioelectrosynthesis (MES) and microbial fuel cells (MFCs).

This presentation highlights the latest advances in leveraging PPB for resource recovery from organic waste. These developments have been propelled by the PurpleGain COST Action and by large European projects focusing on waste and wastewater treatment. Key challenges and opportunities include scaling up photobioreactors—exemplified by AQUALIA's anaerobic raceways—along with emerging gas-fed and electrochemical systems, and established applications in domestic wastewater and urban organic waste treatment. The talk will also explore growing market segments such as the food and cosmeceuticals industries, where highly promising PPB-derived components are attracting increasing industrial interest and are poised for rapid expansion in the coming years.

Corresponding author email: daniel.puyol@urjc.es

INERTIAL BALLISTIC MICROFLUIDICS AS A PLATFORM FOR CHEMICAL ENGINEERING APPLICATIONS

David F. Rivas, [1,2*] ***Ulisses J. Gutiérrez Hernández,*** [1] ***Keerthana Mohan,*** [1] ***Akash Raman,*** [1] ***Arturo Susarrey Arce,*** [1] ***Ian Hunter,*** [2] ***Gareth McKinley,*** [2] ***Andrew K. Dickerson,*** [3] ***Miguel A. Quetzer*** [4]

[1]*University of Twente, The Netherlands,* [2]*Massachusetts Institute of Technology, USA,* [3]*University of Tennessee, USA,* [4]*Universidad Nacional Autónoma de México, Mexico*

Abstract

Controlling physicochemical phenomena like mixing and encapsulation is possible at the microscale with droplets and bubbles. Our team has developed the BuBble Gun platform to accelerate small liquid volumes, with utilization potential in biomedical and chemistry applications. We propose to the broader Greenering community three main testing frameworks:

1) Cavitation: the actuation is done with lasers, where the optical energy absorption by a liquid in a microchannel lead to an explosively growing bubble. We will share unpublished results using gold coating and compare them with our previous work with dyed liquid for increased absorption. Besides advanced heat transfer studies including additives such as nanoparticles, we investigate ultrafast contact line dynamics.

2) Jetting: the growing bubble displaces the liquid in the microchannel, resulting in fast traveling droplets that can stretch into jets. The channel geometry and internal coatings influences the jet breakup, the resulting drop size distribution, the trajectory of the jet, and the consistency of jetting across trials. The range of Reynolds number ~150−3200 indicates inertia dominated jets. We will present new results on viscoelastic effects and break up dynamics for different additives.

3) Impact: we have studied jet impacts onto e.g., hydrogels with precise control over volumes (pL to mL) and penetration depths (μm to mm), without changing the microfluidic device, by varying parameters such as laser power, beam diameter and filling level of the liquid container. We will present new results of how laser-induced cavitation can be used to operate novel jet-stirred reactor microfluidics and increase the mixing inside droplets, and to enhance mass transport with bubble formation in e.g., electrochemical systems.

These three frameworks offer advantages for manipulating viscous forces, surface tension, thermal gradients, and mass transport, which are concomitant factors in chemical processes.

Keywords: microchemical systems, cavitation, micromixing, jetting

Corresponding author email:d.fernandezrivas@utwente.nl

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VALORIZATION OF GREENHOUSE CARBON DIOXIDE EMISSIONS INTO H_2 AND VALUE-ADDED PRODUCTS BY CATALYTIC PROCESSES

Liotta L.F.

Institute for the Study of Nanostructured Materials (ISMN)-CNR

Via Ugo La Malfa, 153, 90146, Palermo, Italy

Abstract

Global warming is a critical issue that has become increasingly pressing in recent years due to the high levels of CO_2 emissions resulting from the use of fossil fuels. As global energy demands continue to rise and conventional fossil fuel reserves dwindle, the need for sustainable alternatives becomes increasingly urgent. In this respect, recycling CO_2 into e-fuels is a strategic response to the scarcity of fossil fuels. This study explores innovative catalytic approaches for converting CO_2 into hydrogen and high-value products through three key processes: dry reforming of methane (DRM), chemical looping reforming (CLR), and CO_2 methanation. The dry reforming of methane utilizes CO_2 and methane to produce syngas (a mixture of H_2 and CO), presenting an effective method for reducing greenhouse gas emissions, while generating valuable chemical feedstocks. Chemical looping reforming further enhances efficiency by using metal oxides to transfer oxygen, minimizing energy consumption and maximizing carbon utilization. CO_2 methanation converts CO_2 into methane, enabling the production of synthetic natural gas, which can be integrated into existing energy infrastructures. All these catalytic processes not only facilitate the recycling of CO_2 into useful energy carriers, but also contribute to the development of a circular economy by creating products with added value. Supported nickel-based catalysts are successfully employed for all the above-mentioned reactions. The nature of the support and the preparation methods are crucial in order to design active and stable catalysts with the lowest Ni loading, proper particle size and good metal-support interaction, having tailored redox properties and enhanced catalytic performances.

In this work, recent advances of the research group in the design of novel Ni-based catalytic devices for sustainable CO_2 conversion processes will be presented.

Keywords: CO_2 valorization, CH_4 dry reforming reaction, chemical looping reformimg, CO_2 methanation

Corresponding author email:leonardafrancesca.liotta@cnr.it

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EMBRACING GREEN TECHNOLOGIES IN THE COSMETICS INDUSTRY: INNOVATIONS FOR A SUSTAINABLE FUTURE

Vasillatou K.

The Nuclab, El. Venizelou 3, 17456, Athens, Greece

Abstract

The cosmetics industry is undergoing a transformative shift toward sustainability, driven by the integration of green technologies and eco-conscious practices. This presentation explores key advancements shaping the future of cosmetics, focusing on innovative approaches that minimize environmental impact while addressing consumer demands for safer, ethical products.

Key topics include the adoption of biodegradable and recyclable packaging to combat plastic waste, the use of plant-based and non-toxic ingredients to promote safety and environmental health, and the implementation of sustainable sourcing practices to protect ecosystems. Advances in waterless formulations highlight the industry's commitment to conserving water and reducing transportation-related carbon footprints. The presentation also delves into the adoption of renewable energy sources, the application of green chemistry principles, and the development of closed-loop production systems that recycle waste materials.

Additionally, initiatives such as carbon offset projects underscore the industry's proactive approach to neutralizing emissions and fostering environmental sustainability. By embracing these innovations, the cosmetics industry is paving the way for a greener, more responsible future. This discussion will provide valuable insights into the opportunities and challenges associated with sustainable transformation in the cosmetics sector.

Keywords: sustainable sources, waterless products, renewable energy, green chemistry, carbon offsetting

Corresponding author email: katerina.vassilatou@thenuclab.com

NANOFLUIDS AND SYNTHETIC ENZYMES FOR THE INTENSIFICATION OF CARBON CAPTURE BY MEANS OF REACTIVE ABSORPTION PROCESS

***Vilardi G.*[1]**

[1]*Department of Chemical Engineering Materials Environment, Sapienza University of Rome, Via Eudossiana 18, 00184 Rome, Italy*

Abstract

Reactive absorption still represents the TRL9 technology adopted in post-combustion carbon (PCC) capture processes for the decarbonization of hard to abate industrial sectors. This technology is mainly based on the use of aqueous solutions of amines that are well-known from 1930 for their capacity to react with carbon dioxide and other acid gases (i.e. H_2S) in a reversible way. Two main drawbacks are related to this technology: environmental impact (amine aerosols, toxic leakages, carbon footprint related to their synthesis, hazardous handling) and high regeneration costs (>60% of total costs). The use of greener solvents, such as K_2CO_3, surely can lead to reduced environmental impact but to lower efficiency and generally to higher costs (in particular CapEx). To overcome these limits, the addition of metal oxide nanoparticles-NPs as well synthetic enzymes-SE (that mimic the carbonic anhydrase behavior) has been tested and demonstrated to be effective in CO_2 capture and sequestration. This work deals with the presentation of the most important findings related to the adoption of NPs and SE in green solvents for the PCC application fields, showing the possible CapEx and OpEx reduction achievable by the use of TiO_2 NPs adoption, in comparison to the classic absorbent benchmark MEA30%wt in aqueous solution.

Keywords: CO2, mimic-enzymes, reactive-absorption, nanofluids, CCSU

Corresponding author email: giorgio.vilardi@uniroma1.it

1. Alternative green solvents and related technologies and processes

Oral presentations

SELECTIVE DEEP EUTECTIC SOLVENT-MEDIATED LEACHING OF VALUABLE METALS FROM ELECTRONIC WASTE USING ETHYLENE GLYCOL AS ADDITIVE

Alaydaroos A., Chola N., Stephen S., AlNashef E., Elkadi M., Abi Jaoude M.

Khalifa University of Science and Technology, Sas Al Nakhl Campus, Al Yahhal Street, P.O. Box 127788, Abu Dhabi, United Arab Emirates

Abstract

The increasing amount of discarded printed circuit boards (PCBs) in electronic waste presents both a serious environmental concern and a potential for material recovery. Deep eutectic solvents (DESs) have recently emerged as environmentally friendly alternatives to conventional, hazardous extraction methods in metallurgy. In this study, a ternary DES system made up of choline chloride (ChCl), oxalic acid (OA), and ethylene glycol (EG) was used at different molar ratios (1:1:x), where x = 0, 0.25, 0.5, 0.75, and 1) to recover valuable metals from PCBs, with copper (Cu), aluminum (Al), nickel (Ni), zinc (Zn), and tin (Sn) being the primary elements extracted. It was observed that increasing the amount of EG lowered both the density and acidity of the DES. The FT-IR spectrum showed a broad band at 3313 cm^{-1}, indicating that the addition of EG disrupted the hydrogen bonds between ChCl and OA. Leaching tests were conducted at room temperature, 40 °C, 50 °C, and 60 °C over 72 hours under static conditions. ICP-MS results revealed that Cu and Sn were selectively leached from the PCBs, regardless of the DES composition or temperature. The yellow color of the leachates confirmed the presence of a copper(II) chloride complex. Higher temperatures improved metal dissolution, likely due to enhanced mass transfer and reaction kinetics with mild heating. Above 50 °C, the (1:1:0) and (1:1:0.25) DES systems solidified, suggesting that the release of metal ions into DES systems with little or no EG interfered with the hydrogen bonding, possibly forming oxalate complexes or precipitates. Thus, EG plays a critical role in maintaining the liquid structure of DES during the leaching process, especially at elevated temperatures.

Keywords: E-waste, Deep eutectic solvent (DES), Metal leaching, Hydrogen bonding

Corresponding author email: alia.alaydaroos@ku.ac.ae

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SUPERCRITICAL CO_2: A SUSTAINABLE ALTERNATIVE TO STERILIZE POLYMERIC IMPLANTABLE MEDICAL DEVICES

Warambourg V.[1], Zhang J.S.[2], Mouahid A.[1], Crampon C.[1], Galinier A.[3], Masmoudi Y.[1], Temelli F.[2], Ganzle M.G.[2], Badens E.[1]

[1]Aix Marseille Univ, CNRS, Centrale Marseille, M2P2, Marseille, France
[2]University of Alberta, Edmonton, T6G 2R3, Canada
[3]Aix Marseille Univ, CNRS, LCB, Marseille, France

Abstract

Implantable medical devices are currently mainly sterilized using gaseous ethylene oxide treatment or γ-irradiation. Sterilization using ethylene oxide might be soon prohibited because of health concerns since ethylene oxide is genotoxic and carcinogenic, and □-rays might alter the mechanical properties of polymeric medical devices. The project FasteCO_2 (2020-2024) which involved two French manufacturers of medical devices, Lattice Medical and Cousin Surgery, and academic laboratories, aimed to implement a green and economically viable sterilization method that can be applied at large scale to polymeric implantable medical devices. Supercritical CO_2 ($scCO_2$) was evaluated as an alternative to conventional sterilization methods since this environmentally friendly solvent has already proven effectiveness for the inactivation of resistant microorganisms under high pressure and high temperatures. The challenge of the FasteCO_2 project proposed a sterilization method involving $scCO_2$ at pressures lower than 300 bar and temperatures lower than 50 °C to preserve the polymeric material properties, while achieving at least a 6-log bacterial reduction to meet the Sterility Assurance Level imposed by EN 556-1:2002 standards. In the first step, the $scCO_2$ sterilization of *Bacillus subtilis,* a Gram-positive spore-forming bacterium, was assessed and operating conditions were optimized through an experimental design. The best operating conditions were: 20 min $scCO_2$ treatment at 110 bar, 40°C with the addition of 200 ppm of H_2O_2. In the second step, the efficiency of $scCO_2$ treatment was confirmed on other microorganisms, including endospore-forming bacilli and vegetative cells of nosocomial pathogens, to understand the mechanisms of action of $scCO_2$ in microbial inactivation. Remarkably, vegetative cells of *Salmonella* and *Klebsiella* were as resistant or more resistant than bacterial endospores and $scCO_2$ at 110 bar, 40°C with 200 ppm of H_2O_2 and 400 ppm of peracetic acid was necessary to achieve a 6-log reduction. A consortium of 18 companies is working on a draft of standards targeting the application of $scCO_2$ sterilization method at industrial scale for implantable medical devices.

Keywords: sterilization, supercritical CO_2, medical device

Corresponding author email: christelle.crampon@univ-amu.fr

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SUPERCRITICAL CO_2 FRACTIONATION: CASE STUDIES FROM PERFUME TO ENERGY APPLICATIONS

***Crampon C.*[1], *Fabien A.*[1], *Dufour C.*[2], *Pieck A.*[1], *Badens E.*[1]**

[1]*Aix Marseille Univ, CNRS, Centrale Marseille, M2P2, Marseille, France*
[2]*Bontoux SAS, 583 route du col de Peyruergue, 26170 Saint-Auban-sur-l'Ouvèze, France*

Abstract

Despite their toxicity, flammability and often low selectivity, industry still uses organic solvents such as *n*-hexane or acetone. An alternative to their use is to implement processes using supercritical carbon dioxide which is recognized by the U.S. Food and Drug Administration (US FDA) as a GRAS solvent. This non-polar solvent is rather selective towards low polarity compounds and this selectivity can be modulated by varying pressure and temperature. The recovery of the targeted solute or its separation from the supercritical fluid is done spontaneously by simple depressurization since CO_2 is gaseous and loses its solvent power under ambient conditions of pressure and temperature; products from processes using supercritical CO_2 are therefore free of traces of solvents. Finally, the critical temperature and pressure of CO_2 are easily accessible (Tc = 31.1 °C; Pc = 73.8 bar), in particular the critical temperature that allows working with temperature-sensitive compounds. To summarize, processes involving supercritical CO_2 are sustainable, compact, scalable, and economically viable depending on the application.

Among such separation processes, supercritical CO_2, fractionation is devoted to the treatment of liquid mixtures and suspensions. This continuous operation is performed in counter-current packed columns and leads to very fine separations for applications in perfumery, cosmetics, food, and energy fields.

In this presentation, the principle of supercritical CO_2 fractionation will be presented, and the potential of the process will be illustrated through industry/academic collaborations in the field of perfumery for the recovery of a high content in sclareol fraction from a clary sage concrete, and in the field of energy with the purification of oils in view to produce biofuels. Finally, supercritical CO_2 fractionation was successfully applied to microalgae suspension (patent PCT/EP2017/065971) to recover neutral lipids with the great advantage to skip the drying step of the microalgae and to allow then a continuous production of compounds of interest.

Keywords: Separation, Supercritical CO_2, fractionation, energy, suspension

Corresponding author email: Christelle.crampon@univ-amu.fr

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SUPERCRITICAL CO_2 EXTRACTION OF ERGOSTEROL: A GREEN APPROACH WITH SHIITAKE MUSHROOMS

***Faustino R.*[1], Bronze M. [1,2,3], Fernández N.[1]**

[1] *iBET, Instituto de Biologia Experimental e Tecnológica, Apartado 12, 2780-157, Oeiras, Portugal.*
[2] *iMed.ULisboa, Faculdade de Farmácia, Research Institute for Medicines, Universidade de Lisboa, Avenida Professor Gama Pinto, 1649-003 Lisboa, Portugal.*
[3] *Instituto de Tecnologia Quimica e Biologica Antonio Xavier, Universidade Nova de Lisboa, Av. da República, 2780-157 Oeiras, Portugal.*

Abstract

Cardiovascular diseases, linked to high cholesterol levels, are a leading cause of death in developed countries. While effective, cholesterol-lowering drugs have side effects, driving the search for alternatives. Mushrooms contain ergosterol (ERG), a natural cholesterol-lowering agent, and using their nonmarketable biomass supports a circular economy.

This study aims to optimize the extraction of ERG from mushrooms using Supercritical Fluid Extraction (SFE). The obtained SFE extracts were analyzed by GC-MS, and ERG concentration was quantified using a cholecalciferol-based calibration curve. Shiitake mushrooms (328.46 ± 10.26 $mg_{ERG}/100g_{dw}$ – ERG amount quantified after Soxhlet extraction with *n*-hexane) were used as a model.

Based on preliminary results, some extraction parameters were fixed, including particle size (63–250 μm), biomass quantity (10 g), CO_2 flow rate (20 g/min), and extraction time (3 h), while varying pressure, temperature, and the co-solvent (ethanol) amount for further optimization. Response Surface Methodology (RSM) was applied using MODDE® software to model the influence of temperature (40–70°C), pressure (350–800 bar), and co-solvent flow rate (0–10 ml/min) on mass extraction yield ($mg_{extract}/g_{mushroom}$) and ERG concentration ($mg_{ERG}/g_{extract}$). Data analysis revealed a range of extraction mass yield of 0.82% to 6.48% and ERG concentrations in the extracts varied from 180.87 to 682.26 $mg_{ERG}/g_{extract}$.

SFE is a promising method for extracting ERG from Shiitake mushrooms, being sustainable and yielding ERG-rich extracts.

Keywords: Mushrooms, By-products, Ergosterol, Supercritical Fluid Extraction, Design of experiments

Corresponding author email: rita.faustino@ibet.pt

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ENHANCED REMOVAL OF PHARMACEUTICAL COMPOUNDS FROM AQUEOUS SOLUTION USING DEEP EUTECTIC SOLVENTS - IMPREGNATED GRAPHENE OXIDE

Anjali G.[1,2], Tarek L. [1,2,3], Hasan Shadi W.[1,2,3], Hassan A.[1,2,3], Nashef M. Al I. [1,2,3]

[1] *Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, PO Box 127788, United Arab Emirates*
[2] *Center for Membranes and Advanced Water Technology (CMAT), Khalifa University of Science and Technology, Abu Dhabi, PO Box 127788, United Arab Emirates*
[3] *Research & Innovation Center for Graphene and 2D Materials (RIC-2D), Khalifa University, Abu Dhabi, PO Box 127788, United Arab Emirates*

Abstract

The World Health Organization has designated antimicrobial resistance (AMR) as a "silent pandemic," with an annual mortality rate that could soar to 10 million by 2050. A prominent factor contributing to AMR is the persistence of antibiotics in aquatic environments, threatening marine ecosystems and human health.
Traditional water treatment methodologies actually not effectively mitigating these pollutants. This study innovates with deep eutectic solvents (DESs) as impregnating agent on graphene oxide (GO) to significantly enhance the removal of antibiotics from water bodies.
Graphene oxide, promising candidate among carbonaceous adsorbents, provides an extensive surface area and superior adsorption characteristics, serves as an ideal framework for adsorption process. However, GO efficiency can be further enhanced through impregnation with DESs, renowned for their tunable properties and environmental sustainability. This synergistic combination is relatively unexplored avenue in removal targeted pollutants. A straightforward impregnation method used to synthesize DES-impregnated GO materials and subjected to employ various characterization techniques such as Fourier-Transform Infrared Spectroscopy (FTIR), UV-Vis Spectroscopy, Total Organic Content (TOC), Scanning Electron Microscopy (SEM), and X-ray Diffraction (XRD). A batch adsorption study was conducted to optimize contact time, pH, and adsorbent dosage, aimed to maximize removal efficiency.
The research findings are significant, demonstrating that both pristine and DES-impregnated GO materials exhibit remarkable adsorption efficiency, with removal rates of 86.75 mg/g and 98.40 mg/g, respectively, for a targeted antibiotic. The adsorption behavior closely follows a pseudo-first-order kinetic model and the Langmuir isotherm, indicative of monolayer adsorption on a uniformly distributed surface. These results underscore the potential of this novel approach in water treatment, contributing significantly to addressing the AMR challenge.

Keywords: Antibiotics; Antimicrobial resistance; Deep eutectic solvent;Graphene oxide;

Corresponding author Email: enas.nashef@ku.ac.ae

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A DUAL PROCESSING STRATEGY TO MANUFACTURE *IN VIVO* TRACEABLE SCAFFOLDS

***Iglesias-Mejuto A.*[1,2], *Laromaine A.*[2], *Pinto Reis C.*[3,4], *García González C. A.*[1]**

[1]*AerogelsLab, I+D Farma Group (GI-1645), Department of Pharmacology, Pharmacy and Pharmaceutical Technology, Faculty of Pharmacy, iMATUS and Health Research Institute of Santiago de Compostela (IDIS), Universidade de Santiago de Compostela, E-15782 Santiago de Compostela, Spain.*
[2]*Institut de Ciència de Materials de Barcelona, ICMAB-CSIC, Campus UAB, 08193 Bellaterra, Spain.*
[3]*Research Institute for Medicines (iMed. ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Av. Professor Gama Pinto, 1649-003, Lisboa, Portugal.*
[4]*Instituto de Biofísica e Engenharia Biomédica (IBEB), Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016, Lisboa, Portugal.*

Abstract

The technology of supercritical fluids can be successfully employed for the manufacture of aerogel scaffolds for tissue engineering purposes. The recently proposed win-win combination of 3D-printing and supercritical fluids approaches can yield aerogels with improved performances, such as a controlled drug release over time, an improved physicochemical and biological performances and the capability of being long-term traceable structures once *in vivo* implanted. In this work, upconversion nanoparticles-loaded scaffolds were obtained by this dual processing strategy to yield traceable aerogels by fluorescence-based bioimaging. Physicochemical and biological performances of the resulting structures were studied by confocal, scanning and transmission electron microscopies, nitrogen adsorption-desorption analysis and several cell studies. Murine models were also employed to test the *in vivo* biocompatibility and the bioimaging performance of the aerogel formulations. The upconversion nanoparticles-loaded aerogel scaffolds represent a promising alternative towards the development of *in vivo* long-term traceable implants.

Keywords: Aerogel scaffold, upconversion nanoparticles, supercritical fluids technology, 3D-printing

Reference: Iglesias-Mejuto A, Pinto R, Faísca P, Catarino J, Rocha J, Durães L, Gaspar MM, Pinto Reis C, García-González CA. 3D-printed aerogels as theranostic implants monitored by fluorescence bioimaging. Bioact. Mater. 2024; 41:471.

Corresponding author email: ana.iglesias.mejuto@rai.usc.es

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A COMPARATIVE STUDY ON SEQUENTIAL GREEN HYBRID TECHNIQUES FOR THE EXTRACTION OF DATE SEED BIOACTIVE COMPOUNDS AND ITS APPLICATION AS AN ADDITIVE FOR SHELF-LIFE EXTENSION OF *OREOCHROMIS NILOTICUS*

Osamede A. J. [1], ***Sajid M.*** [1,2]

[1]*Department of Food Science, College of Agriculture and Veterinary Medicine, United Arab Emirates University, Al-Ain 15551, UAE*
[2] *Water and Energy Centre, United Arab Emirates University, Al-Ain, 15551, United Arab Emirates.*

Abstract

This study focuses on the extraction of bioactive compounds from date seeds using five polyol-based deep eutectic solvents (P-DESs) in combination with hybrid green extraction techniques, specifically microwave-assisted extraction (MAE), homogenization-assisted extraction (HAE), and ultrasound-assisted extraction (UAE). The optimization of these extraction techniques was achieved using P-DESs showing the highest efficiency for extracting date seed bioactive compounds using response surface methodology (RSM) and central composite design (CCD). The optimized conditions from the three green techniques were further applied in the form of hybrid green extraction techniques, involving six binary and three ternary methods, to assess the percentage increase in the extraction efficiency of date seed bioactive polyphenolics. Among the five P-DESs tested, choline chloride: ethylene glycol (ChCl:Eg) exhibited the highest extraction efficiency for recovering date seed phenolic compounds. Using ChCl:Eg as the P-DES, the highest extraction efficacy was found with MAE, followed by > HAE and > UAE. In addition, all hybrid extraction techniques showed higher extraction efficiencies than the single extraction methods. Notably, the binary hybrid techniques combining UAE and MAE (UMAE), HAE and MAE (HMAE) resulted in significantly higher recovery of bioactive compounds, with 52% and 49% increases in total phenolic content, respectively, compared to single extraction techniques. The lowest MIC and MBC of P-DES (ChCl:Eg) and date seed P-DES based extract recorded against all the tested bacterial strains was 40% and 20% respectively. Furthermore, the date seed extract from MAE was used to extend the shelf life of *Oreochromis niloticus* fillets stored at 4°C for 10 days. The results indicated that the date seed polyphenolic extract effectively inhibited microbial growth in *Oreochromis niloticus* fillets during refrigerated storage, with the total bacterial count (TBC) of all the treated samples within the recommended acceptability limit of < 6 log CFU/g compared to the untreated samples, which showed a total bacterial count (TBC) > 6 log CFU/g. This study demonstrated that sequential hybrid techniques enhance and intensify the recovery of bioactive compounds more effectively than any single green technique.

Keywords: green extraction techniques, hybrid extraction techniques, deep eutectic solvent, date seed, shelf-life study

Corresponding author email: Sajid Maqsood (sajid.m@uaeu.ac.ae)

INTEGRATING DEEP EUTECTIC SOLVENTS IN DRUG SYNTHESIS: A PATH TOWARD ECO-FRIENDLY PHARMACEUTICAL MANUFACTURING

***L. Domingues, A. R. C. Duarte, A. R. Jesus*[1]**

[1] *LAQV-REQUIMTE, Chemistry Department, NOVA—School of Science and Technology, 2829-516 Caparica, Portugal*

Abstract

The increase in life expectancy is leading to an exponential increase in the world's population, originating new diseases and new pathologies. This causes an increased demand for new drugs and chemical-based care products. But the pharmaceutical industry faces increasing pressure to adopt sustainable practices due to growing environmental concerns. This industry is amongst the highest producers of solvent-related waste, having a detrimental effect on the environment. So, it is urgent to find alternative solutions, able to replace these toxic and polluting solvents and processes for the manufacture of pharmaceuticals. Deep eutectic solvents (DES) have emerged as promising green alternatives due to their biodegradability, low toxicity, and versatility in chemical reactions. Their production is 100% atom efficient, and no waste is generated during their production.

In this work, we focused on the synthesis of fluoroquinolones as an example of how DES can replace volatile organic solvents in a synthetic pathway. Our results showed that for the total synthesis of ciprofloxacin (Figure 1), a highly prescribed fluoroquinolone antibiotic, DES can play an important role, successfully replacing organic solvents such as dimethylformamide (DMF) or dioxane in most steps. We were able to decrease reaction time and temperature while increasing the reaction yield by using DES as solvents.

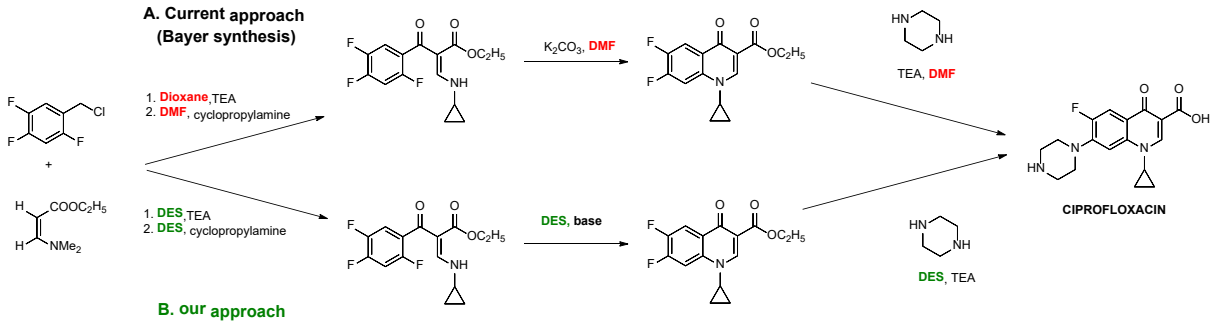

Figure 1: Current approach *vs* our approach for the synthesis of fluoroquinolones using DES as alternative sovlents.

This work will pave the way for the incorporation of DES in synthetic strategies so that the impact on the environment using traditional organic solvents can be significantly decreased.

Keywords: organic synthesis, APIs, green chemistry, deep eutectic solvents

Corresponding author email: ar.gameiro@fct.unl.pt

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EVALUATING HORN AND WATER BATH ULTRASONICATION PRETREATMENT FOR ENHANCED PROTEIN AND PHYCOCYANIN EXTRACTION FROM *SPIRULINA PLATENSIS* USING A LIQUID TRIPHASIC FLOTATION SYSTEM

Kobbin K.[1], Qin U. Y.[1], Norazhar N.[1], Mohd Nor M. Z.[1,2], Mokhtar M. N.[1], Shamsudin R.[1,2], Show P. L.[3]

[1] Department of Process and Food Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[2] Laboratory of Halal Science Research, Halal Products Research Institute, University Putra Malaysia, Putra Infoport, 43400 UPM Serdang, Selangor, Malaysia
[3] Department of Chemical Engineering, Khalifa University, P.O. Box 127788, Abu Dhabi, United Arab Emirates

Abstract

Spirulina platensis, a cyanobacterium rich in protein and phycocyanin, presents a promising source of protein. Ultrasonic pretreatment followed by a liquid triphasic flotation system (LTFS) can serve as a green technology to enhance the extraction of protein and phycocyanin from *S. platensis*. This study aimed to compare the effects of two different ultrasonication setups (horn and water bath) as pretreatment step for the extraction of protein and phycocyanin from *S. platensis* by LTFS. The one-variable-at-a-time (OVAT) method and analysis of variance (ANOVA) were used to determine the optimal parameters for the ultrasonic pretreatment. Additionally, the characteristics of proteins and phycocyanin (C-PC) extracted from *S. platensis* after the LTFS process were investigated. The optimal conditions for water bath ultrasonication were 45°C, a treatment duration of 40 minutes, a solute-to-solvent ratio of 0.1 (w/v), and a buffer concentration of 0.1 M. For horn ultrasonication, the optimal conditions were 30% amplitude, a solute-to-solvent ratio of 0.1 (w/v), a buffer concentration of 0.1 M, and a treatment duration of 5 minutes. The findings after LTFS showed that horn ultrasonic pretreatment was more effective, resulting in higher protein recovery yield (67.26±3.61%), protein separation efficiency (78.14±0.17%), and C-PC recovery yield (60.61±1.74%) compared to water bath ultrasonication (54.31±0.86%, 72.77±0.05%, 56.70±3.65%, respectively). Moreover, SEM analysis demonstrated that ultrasonication could rupture the cell wall and enhance the release of protein and C-PC from spirulina. FTIR and SDS-PAGE analysis also confirmed the separation of these two components from spirulina. The findings of this study indicate the successful use of a combination of ultrasound and LTFS to extract protein and C-PC from *S. platensis*.

Keywords: Cyanobacteria, liquid triphasic flotation system, phycocyanin, protein, spirulina.

Corresponding author email: zuhair@upm.edu.my

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OPTIMIZATION BIOACTIVE COMPOUND EXTRACTION FROM *ROSA CANINA* L. PSEUDOFRUIT THROUGH SYNERGISTIC ACTION OF TWO HYDROLYTIC ENZYMES

Lemoni Z.[1], Kalantzi S.[1], Lymperopoulou T.[2], Tzani A.[3], Detsi A.[3], Mamma D.[1]

[1]Biotechnology Laboratory, Zografou Campus, School of Chemical Engineering, National Technical University of Athens, 15780 Athens, Greece
[2]Processes and Products Quality Control Horizontal Laboratory, Zografou Campus, School of Chemical Engineering, National Technical University of Athens, 15780 Athens, Greece
[3]Laboratory of Organic Chemistry, Zografou Campus, School of Chemical Engineering, National Technical University of Athens, 15780 Athens, Greece

Abstract

The pseudo-fruit of *Rosa canina L.* is a rich source of bioactive compounds with antioxidant, anti-inflammatory, anti-cancer, anti-diabetic, anti-aging and antimicrobial activities, among others. Enzyme-assisted extraction (EAE) is a green technology, which exhibits important advantages regarding bioactive compounds extraction, since it is a simple process that does not involve the use of organic solvents, while low power consumption, time and temperature are required to achieve significant extraction yields. EAE is based on the enzymes ability to disrupt the cellular wall to release bioactive compounds bound to it. The aim of the present study is the optimization of a green process based on the synergistic action of two hydrolytic enzymes (hemicellulases and pectinases) for the extraction of bioactive compounds from the pseudo-fruit of *Rosa canina L.* of Greek origin, as well as the evaluation of the biological activities of the optimum extract. A Box–Behnken Design–Response Surface Methodology (BBD–RSM) experimental design was applied to determine the optimal conditions of EAE. The variables were the enzyme load of Pectinex® Ultra Color (pectinolytic enzyme), the enzyme load of Viscoferm® (hemicellulolytic enzyme), and extraction time. The responses were the total phenolic content (TPC), total flavonoid content (TFC), and the antioxidant activity (IC_{50}). The TPC was determined using the Folin–Ciocalteu method, the TFC with the Dowd method, and the antioxidant activity was evaluated with the DPPH radical scavenging method. Simultaneous optimization of the three responses was performed using Derringer's desirability function method. The optimum extract was characterized for its antimicrobial activity (against *Escherichia coli*, by broth microdilution method), anti-aging activity (tyrosinase inhibition), and anti-diabetic activity (a-glucosidase inhibition & a-amylase inhibition). The optimal conditions were found enzyme load of 0.59% for Pectinex® Ultra Color, and 0.51% for Viscoferm®, with an extraction time of 97 minutes, achieving a desirability (D) value of 0.70. The optimum values of the responses were: TPC 122 $mg_{GAL}/g_{raw\ material}$, TFC 46 $mg_{CAT}/\ g_{raw\ material}$ and IC_{50} 0.99 $\mu L_{extract}/mL_{solution}$. The optimum extract showed 81% inhibition of the *E. coli* growth, while 73% anti-aging activity and 36% inhibition of a-glucosidase and 37% inhibition of a-amylase.

Keywords: Rosa canina L. pseudo-fruit; Enzyme Assisted Extraction (EAE); Box-Behnken experimental design; synergistic action; biological activities

Corresponding author email: Mamma Diomi; dmamma@chemeng.ntua.gr

SUPERCRITICAL PROCESSES APPLIED TO THE ELABORATION OF DRUG DELIVERY SYSTEMS

***Masmoudi Y.*[1], Laggoune Z.[1,2], Schneider M. [1,3], Badens E. [1]**

[1]*Aix Marseille Univ, CNRS, Centrale Med., M2P2, Marseille, France*
[2] *AlchiMedics S.A.S., Paris, France*
[3]*Laboratoires Théa, Clermont-Ferrand, France*

Abstract

Targeting drugs to specific organs and tissues is a key challenge in the medical and biomedical fields, requiring continuous exploration of innovative approaches for the development of delivery systems. Many drug delivery systems are polymer-based to enable sustained drug release while protecting the drug from harsh external conditions and preventing premature clearance. However, the traditional use of organic solvents in polymer-based drug delivery systems raises ecological concerns, as well as issues related to residual solvents in the final product. Stricter regulations are driving the need for the development of solvent-free manufacturing processes. In this context, supercritical CO_2 technology emerges as a highly promising, sustainable alternative.

Thanks to the unique properties of supercritical CO_2 tunable between those of liquids and gases, and its plasticizing effect on polymers, several processes can be applied depending on the specific polymers and drugs involved. In this presentation, two distinct processes will be highlighted, supported by two case studies in collaboration with pharmaceutical and medical device companies.

First, the supercritical impregnation processes in which supercritical CO_2 is used as a drug carrier within polymer or polymer-coated medical devices will be discussed, highlighting the different interaction phenomena involved. A recent study on the development of active stents for interventional cardiology using the supercritical impregnation process will be addressed.
Second, the Particles from Gas Saturated Solutions (PGSS) process, which utilizes supercritical CO_2 to assist polymer melting or softening under mild temperature conditions, will be introduced. This technology offers the possibility of encapsulating therapeutic molecules that are insoluble or have low solubility in supercritical CO_2. An example of encapsulating macromolecules in biodegradable polyesters (Polycaprolactone and poly(Lactide-co-Glycolide)) for application in the development of innovative intravitreal delivery implants will be presented.

Keywords: Supercritical CO_2, High pressure processes, drug delivery systems, impregnation, encapsulation.

Corresponding author email: yasmine.masmoudi@univ-amu.fr

PRODUCTION OF NOVEL DABAI PULP-BASED MARKER INK: PROCESS OPTIMIZATION, PHYSICO-CHEMICAL AND MORPHOLOGY ANALYSIS

***Hamzah M. H.*[1,2], *Surik S. R. A.*[2], *Hamzah A. F. A.*[2], *Shamsudin R.*[3], *Basri M. S. M.*[3], *Nor M. Z. M.*[3], *Ali A. H. M.*[4]**

[1] *Smart Farming Technology Research Centre, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[2] *Department of Biological and Agricultural Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[3] *Department of Process and Food Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*
[4] *Department of Chemical and Environmental Engineering, Malaysia-Japan International Institute of Technology, University Technology Malaysia, Jalan Sultan Yahya Petra, 54100, Kuala Lumpur, Malaysia*

Abstract

Dabai pulp can be utilized as a sustainable source of marker ink. Nonetheless, research into this abundant resource has not been conducted. This work investigated the development and optimization of novel dabai pulp-based marker ink utilizing Response Surface Methodology with a central composite design. The production of dabai pulp-based marker ink was carried out within the following dabai pulp powder ranges of 50 to 100 g, glycerol of 15 to 62.5 mL, and carboxymethyl cellulose (CMC) of 1 to 12.5 g to obtain the desired ink qualities of viscosity and colour lightness. The results indicated that 12.5 g of dabai pulp powder, 15 mL of glycerol, and 50 g of CMC were the most optimal conditions for creating dabai pulp-based marker ink. Under these optimum conditions, the experimental values for viscosity were 545.32 mPa.s and 32.15 L* for colour lightness, indicating an acceptable match between expected and experimental results, particularly for colour lightness. The viscosity and colour lightness of optimized dabai pulp-based with glycerol were then compared to the produced dabai pulp-based marker ink without glycerol as well as commercial ink. The findings showed that the viscosity and colour lightness of dabai pulp-based marker ink without glycerol and commercial ink were 542.73 mPa.s and 33.15 L*; and 784.03 mPa.s and 23.92 L*, respectively. Thermogravimetric analysis found the commercial marker ink exhibited the fastest drying rate among the three samples. Fourier Transform Infrared Spectroscopy validated the functional groups associated with the produced dabai pulp-based marker ink. Morphological analysis provided evidence that dabai pulp powder with glycerol exhibited aggregation with a considerably smoother and flatter surface. Dabai pulp-based marker ink could be considered a as a feasible and innovative resource for use in non-food applications.

Keywords: Dabai, Marker ink, Optimization, Configuration, Characterization

Corresponding author email: hazwanhamzah@upm.edu.my

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INTRODUCTION OF A NOVEL PLANT EXTRACT COMPOSITION USING MULTICOMPONENT NATURAL DEEP EUTECTIC SOLVENTS (NADES)

***Panić M.*[1], Železnjak M.[1], Benković M.[2], Jurinjak Tušek A.[2], Valinger D.[2] Jurina T.[2], Gajdoš Kljusurić J.[2], Radojčić Redovniković I.** [1,2]

[1]*NADES Design, Borongajska cesta 83H, 10 000 Zagreb, Croatia*
[2] *University of Zagreb, Faculty of food technology and biotechnology, Pierotti street 6, 10 000 Zagreb, Croatia*

Abstract

Introducing a novel composition for plant extracts using a multicomponent Natural Deep Eutectic Solvent (NADES), which includes Choline bitartrate as a crucial ingredient. NADES, a unique liquid solvent, consists of at least one hydrogen bond acceptor, two or three hydrogen bond donors, and water, enhancing the extraction efficiency of bioactive compounds from plants. These extracts are ready to use, as they do not require solvent removal, making them immediately applicable across various industries.

The study aims to assess the effectiveness of NADES in producing ready-to-use plant extracts with improved antioxidant capacity, stability, and enhanced bioavailability and solubility of the compounds. Our presentation will include methodologies for assessing key quality indicators such as total phenolic content, oxygen radical absorbance capacity, and *in vitro* toxicity.

The edible components in NADES comply with safety and regulatory standards, making these extracts particularly valuable for applications requiring high purity and natural composition. Moreover, the favorable sensory properties of these extracts enhance their practical utility. These sensory properties will also be discussed in our presentation.

Eliminating the need for downstream purification, the extraction process is more cost-effective, energy-efficient, and environmentally friendly. This approach not only reduces waste but also preserves the synergistic effects of naturally occurring compounds, enhancing their overall health benefits and aligning with sustainable production goals.

Keywords: Green extraction, Natural Deep Eutectic Solvents (NADES), Plant Extracts, Sensory properties, Sustainability

Corresponding author email: manuela@nades-design.hr

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SUPERCRITICAL CARBON DIOXIDE EXTRACTION OF GRAPE POMACE: ENHANCING RESOURCE EFFICIENCY

Rodrigues L.G. [1,2,3], ***Vági E.M.*** [1], ***Kemény Zs.*** [4], ***Berkó Sz.*** [5], ***Kovács A.*** [5]

[1] *Department of Chemical and Environmental Process Engineering, Budapest University of Technology and Economics, Műegyetem rkp. 3., 1111 Budapest, Hungary*
[2] *University of Technology of Troyes, 12 street Marie Curie, 10300 Troyes, France*
[3] *University of Bari Aldo Moro, Piazza Umberto I 1, 70121 Bari, Italy*
[4] *Katalin Kővári Innovation Center, Bunge Zrt. Illatos út 38., 1097 Budapest, Hungary*
[5] *Institute of Pharmaceutical Technology and Regulatory Affairs, University of Szeged, Faculty of Pharmacy, 6 Eötvös St. 6720 Szeged, Hungary*

Abstract

Grape pomace is the main solid waste fraction from the wine industry and consists of a mixture of skins, seeds and residual stalks therefore contains many components of commercial interest, e.g fatty acids, resveratrol, and flavonoids. Before the final destination of this waste (such as distillation or landfill) is reached, active non-polar compounds can be recovered via supercritical carbon dioxide extraction. This process aligns with green chemistry principles, such as use of renewable feedstocks and using safer solvents and auxiliaries. It also adds up to economic and environmental sustainability, as usually no further separation process is needed. The processing of grape pomace is thus a clear example of waste valorization, which contributes to the no-waste target of circular economy and cascading.

Technologically, this work aims to study the effect of pressure on extraction efficiency using a pilot-scale $scCO_2$ plant operating batch-wise. Experiments were conducted using two different grape pomace samples (GP1, GP2), each with distinct dry contents (89.51%, 84.52%) and origins but harvested simultaneously. Extraction pressures tested were 30, 37.5 and 45 MPa, all at 40°C without any cosolvent, aiming to extract oily compounds.

Extraction yields ranged from 4.31% to 4.89% (grams per 100 grams of dry material) for both pomaces. Increasing pressure had no significant effect on mass yield. However, higher pressures resulted in a faster initial extraction rate, potentially advantageous in industrial applications where only 70-80% of the total extraction time is utilized. The extracts from GP1 and GP2 obtained via 45 MPa extraction contained more than 60% mass composition of linoleic acid (C18:2), followed by around 20% of oleic acid (C18:1) and ~10% of palmitic acid (C16:0). For the most efficient extraction, the calculated environmental factor was 19.47, showing that reducing the waste, as well as improving the yield of the process are strongly advised. Yet, supercritical carbon dioxide extraction might still be preferred, in terms of sustainability, over conventional extraction due to its independence of organic solvents in this case. From the potential cosmetic application point of view the effects of grape pomace extracts on the skin was investigated by testing the skin penetration and UV protective effects of the extracted oils.

Based on our results, it might be possible to validate the feasibility of such a cascade, as long as further economic and environmental assessments are provided.

Keywords: Grape pomace, green extraction, $scCO_2$, fatty acid composition, cosmetic application

Corresponding author email: rodriguesleog@gmail.com, vagierikamaria@gmail.com

STARCH EMULSION TEMPLATE COMPOSITES FOR POTENTIAL BIOLOGICAL APPLICATIONS

Rodríguez-Quesada L. [1,2], ***Alvarado-Hidalgo F.*** [1], ***Formosa-Dague C.*** [3], ***Dague E.*** [4], ***Sáenz-Arce G.*** [2,5], ***García Gonzalez C. A.*** [6], ***Vásquez-Sancho F.*** [7,8], ***Avendaño-Soto E.*** [7,8], ***Starbird-Perez R.*** [1]

[1]*Centro de Investigación en Servicios Químicos y Microbiológicos (CEQIATEC), Escuela de Química, Instituto Tecnológico de Costa Rica, Cartago 159-7050, Costa Rica.*
[2]*Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad Nacional, Heredia 86 3000, Costa Rica.*
[3]*TBI, Université de Toulouse, INSA, INRAE, CNRS, 31400 Toulouse, France.*
[4]*LAAS-CNRS, Université de Toulouse, CNRS, Toulouse, France.*
[5]*Centro de Investigación en Óptica y Nanofísica, Departamento de Física, Universidad de Murcia, 30100 Murcia, Spain*
[6]*AerogelsLab, I+D Farma Group (GI-1645), Department of Pharmacology, Pharmacy and Pharmaceutical Technology, Faculty of Pharmacy, iMATUS and Health Research Institute of Santiago de Compostela (IDIS), Universidade de Santiago de Compostela, Spain*
[7]*Centro de Investigación en Ciencia e Ingeniería de Materiales (CICIMA), Universidad de Costa Rica, San José 11501-2060, Costa Rica.*
[8]*School of Physics, Universidad de Costa Rica, San José 11501-2060, Costa Rica.*

Abstract

The design and processing of starch aerogels has been the object of much research recently, due to a wide range of applications in the medical, environmental, and other engineering fields. Due to its high porosity, pore interconnectivity and high specific surface area starch aerogel monoliths have been employed in tissue engineering as extracellular matrices or as carriers in drug delivery systems. Supercritical drying is one of the most employed processing techniques for obtaining starch aerogels, however, these materials are usually mesoporous. Emulsion templating has been proposed as processing pathway along with supercritical CO_2 drying, to promote the formation of macropores on the aerogel structure. In this work, starch-based porous monoliths were prepared looking forward tissue engineering applications. The starch-templated materials were formulated using κ-carrageenan, polyvinyl alcohol (PVA) and styrylpyridinium-substituted PVA (SbQ). The physical, thermal, and mechanical properties were evaluated for the obtained composites. Our results of the emulsion tempering technique showed changes in the type of porosity. Mechanical compression tests at macro- and nanoscale on the starch-template formulations confirmed the capability of tuning the mechanical response of the composites by the addition of biopolymers in different contents. Data show a clear thermal and mechanical effect due to the polymers in the formulation with a slight difference in the porosity and density among samples. Specifically, κ-carrageenan at 5 wt. %, significantly increased the storage module and decreased the damping behavior effect in the formulations. PVA showed a plasticizing effect on the formulations confirmed by the damping effect and an increase on the storage module along with PVA concentration (up to ca. 20 wt.%). Meanwhile, PVA-SBQ at low concentration (1 and 5 wt.%) enhanced the mechanical properties through a cross-linking process along with its physical stability. The mechanical, thermal, and physical behavior confirmed the potential modulation of

the porous material properties by the biopolymers in the formulation. Our results allow the design of extracellular matrices for specific tissue engineering applications.

Keywords: porosity, macro and nanomechanical properties, composites, starch.

Corresponding author email: larodriguez@itcr.ac.cr

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BREAKTHROUGH HIGHLY-EFFECTIVE REMOVAL OF PERFLUOROOCTANOIC ACID FROM WASTEWATER USING NOVEL NATURAL DEEP EUTECTIC SOLVENTS

Eid S. [1,2]***, Lemaoui T.*** [1,3]***, Darwish A. S.*** [1,2]***, Jaoude M. A.*** [2,4]***,***
Banat F. [1,2]***, Hasan S. W.*** [1,2]***,*** ***AlNashef I. M.*** [1,2,3]

[a] *Department of Chemical and Petroleum Engineering, Khalifa University, P.O. Box 127788, Abu Dhabi, United Arab Emirates (UAE)*

[b] *Center for Membranes and Advanced Water Technology (CMAT), Khalifa University, P.O. Box 127788, Abu Dhabi, UAE*

[c] *Research & Innovation Center for Graphene and 2D Materials (RIC-2D), Khalifa University, P.O. Box 127788, Abu Dhabi, UAE*

[d] *Department of Chemistry, Khalifa University, P.O. Box 127788, Abu Dhabi, United Arab Emirates (UAE)*

Abstract

Addressing the urgent need for environmentally sustainable solutions in water remediation, particularly in tackling persistent emerging contaminants such as perfluorooctanoic acid (PFOA), this work reports for the first-time deep eutectic solvents (DESs) for the extraction of PFOA from aqueous medium. The design framework of the DESs was based on multiple metrics, including extraction performance, density, viscosity, environmental impact, and hydrophobicity. Through the multi-criteria evaluation of ten DESs, trioctylphosphine oxide and lauric acid (TOPO:LauA 1:1) emerged as the superior choice with an exceptional 99.7% extraction efficiency in a single stage only –far outperforming the toluene benchmark's 82.3%– and showing favorable characteristics across all other assessed criteria. Remarkably, this exceptional efficiency of TOPO:LauA was sustained >98% across diverse operational conditions, including a broad pH and temperature spectrum (3–9 pH; 15–100°C), solvent-to-feed ratios down to 1:7, concentrations as low as 0.1 ppm, rapid equilibration within 1 minute, and reusability throughout seven cycles without any observable degradation, as verified by spectroscopic analysis. TOPO:LauA also demonstrated exceptional selectivity for PFOA even when mixed with other per- and polyfluoroalkyl substances (PFAS) and under a complex synthetic wastewater environment. Moreover, computational quantum chemistry modeling was applied, providing insights into the extraction's molecular mechanism, and showing a strong agreement with the experimental findings. The development of this new DES for the extraction of PFAS signifies a critical breakthrough in water treatment, presenting an alternative that surpasses traditional solvents and conventional methods of PFAS removal, such as adsorption and membranes, in terms of efficacy, sustainability, and scalability.

Keywords: Perfluorooctanoic acid; Emerging contaminants; Natural deep eutectic solvents; Sustainable water treatment; Computational quantum chemistry.

Corresponding author email: enas.nashef@ku.ac.ae

GREEN EXTRACTS, BIOACTIVITY SCREENING AND VALORIZATION: ADDRESSING AGEING AND/OR AGE-RELATED DISEASES WITH INNOVATIVE NATURAL SOLUTIONS

Trougakos I. P.

Department of Cell Biology and Biophysics, Faculty of Biology, National and Kapodistrian University of Athens, 15784, Athens, Greece

Abstract

Ageing is a complex molecular process driven by diverse molecular pathways and biochemical events that are promoted by both environmental and genetic factors. Specifically, ageing is defined as a time-dependent decline of functional capacity and stress resistance, associated with increased chance of morbidity and mortality. These effects relate to age-related gradual accumulation of stressors that result in increasingly damaged biomolecules which eventually compromise cellular homeostasis. Nevertheless, the findings that genetic or diet interventions can increase lifespan in evolutionarily diverse organisms indicate that mortality can be postponed. Natural compounds, and in particular green extracts, represent an extraordinary inventory of high diversity structural scaffolds that can offer promising candidate chemical entities which can be valorized in the major healthcare challenge of increasing health span and/or delaying ageing. Our basic research in the fields of ageing and age-related diseases (e.g., cancer, neurodegeneration) along with our *in vitro*, cell-based and *in vivo* screening experimental platforms and disease models will be presented. Also, novel potential molecular targets for screening natural compounds for anti-ageing activity, major success stories as well as the idea that anti-ageing interventions represent a systemic approach that is also effective against age-related diseases will be discussed.

Keywords: ageing/age-related disease, bioeconomy, circular economy, natural product, valorization

Corresponding author email: itrougakos@biol.uoa.gr; web: http://scholar.uoa.gr/itrougakos/hom

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EMBRACING GREEN TECHNOLOGIES IN THE COSMETICS INDUSTRY: INNOVATIONS FOR A SUSTAINABLE FUTURE

Vasillatou K.

The Nuclab, El. Venizelou 3, 17456, Athens, Greece

Abstract

The cosmetics industry is undergoing a transformative shift toward sustainability, driven by the integration of green technologies and eco-conscious practices. This presentation explores key advancements shaping the future of cosmetics, focusing on innovative approaches that minimize environmental impact while addressing consumer demands for safer, ethical products.

Key topics include the adoption of biodegradable and recyclable packaging to combat plastic waste, the use of plant-based and non-toxic ingredients to promote safety and environmental health, and the implementation of sustainable sourcing practices to protect ecosystems. Advances in waterless formulations highlight the industry's commitment to conserving water and reducing transportation-related carbon footprints. The presentation also delves into the adoption of renewable energy sources, the application of green chemistry principles, and the development of closed-loop production systems that recycle waste materials.

Additionally, initiatives such as carbon offset projects underscore the industry's proactive approach to neutralizing emissions and fostering environmental sustainability. By embracing these innovations, the cosmetics industry is paving the way for a greener, more responsible future. This discussion will provide valuable insights into the opportunities and challenges associated with sustainable transformation in the cosmetics sector.

Keywords: sustainable sources, waterless products, renewable energy, green chemistry, carbon offsetting

Corresponding author email: katerina.vassilatou@thenuclab.com

1. Alternative green solvents and related technologies and processes

Flash oral presentations

NUTRITIONAL CHARACTERISTICS, PHYTOCHEMICAL AND ANTIMICROBIAL STUDY OF *VACCINIUM PARVIFOLIUM* L. *(ERICACEA)* LEAF PROTEIN CONCENTRATES

***Sodamade A.*[1], *Bolaji K. A.*[1]**

[1] *Department of Physical Sciences Education, Emmanuel Alayande University of Education, P.M.B 1010, 211101, Erelu, Oyo, Oyo State, Nigeria.*

Abstract

Problems associated with protein malnutrition are still prevalent in third-world countries, leading to the constant search for plants that could serve as nutrients and medicinal purposes. Huckleberry is one of the plants that hasbeen proven useful locally in the treatment of numerous ailments and diseases. A fresh sample of the plant (*Vacciniumpavifolium*) was collected from a vegetable garden situated near the Erelu dam of the Emmanuel Alayande College of Education Campus, Oyo. The sample was authenticated at the Forestry Research Institute of Nigeria (FRIN) Ibadan. The leaves of the plant were plucked and processed for leaf protein concentrates before proximate composition, mineral analysis phytochemical and antimicrobial properties were determined using a standard method of analysis. The results of proximate constituents showed; moisture content; 9.89±0.051g/100g, Ash; 3.23±0.12g/100g, crude fat; 3.96±0.11g/100g and 61.27±0.56g/100g of Nitrogen free extractive.The mineral analysis of the sample showed; Mg; 0.081±0.00mg/100g, Ca; 42.30±0.05mg/100g, Na; 27.57±0.09mg/100g, K; 6.81±0.01mg/100g, P; 8.90±0.03mg/100g, Fe; 0.51±0.00mg/100g, Zn; 0.021±0.00mg/100g, Cd; 0.04±0.04mg/100g, Pb; 0.002±0.00mg/100g, Cr; 0.041±0.00mg/100g Cadmium and Mercury were not detected in the sample. The result of phytochemical analysis of leaf protein concentrates of the Huckleberry showed the presence of Alkaloid, Saponin, Flavonoid, Tanin, Coumarin, Steroids, Terpenoids, Cardiacglycosides, Glycosides, Quinones, Anthocyanin, phytosterols, and phenols. Ethanolic extracts of the *Vacciniumparvifolium L.* leaf protein concentrates showed that it contains bioactive compounds that are capable of combating the following microorganisms; *Staphylococcus aureus, Streptococcus pyogenes, Streptococcus faecalis, Pseudomonas aeruginosa, Klebisialae pneumonia and Proteus mirabilis.* The results of the analysis of*Vacciniumparvifolium L.* leaf protein concentrates showed that the sample contains valuable nutrient and mineral constituents, and phytochemical compounds that could make the sample useful for medicinal activities.

Keywords: Leaf Protein Concentrates, Food Shortage, Antimicrobial activities, Nutritional Composition, Phytochemical.

Corresponding author email: khornskenny@yahoo.co.uk

NADES GOODNESS PLANT EXTRACTS

Železnjak M.[2], Panić M. [1], Radojčić Redovniković I. [1,2]

[1]NADES Design, Borongajska cesta 83H, 10 000 Zagreb, Croatia
[2] University of Zagreb, Faculty of food technology and biotechnology, Pierotti street 6, 10 000 Zagreb, Croatia

Abstract

The industrial use of petroleum-based solvents is a major contributor to environmental pollution, posing significant risks due to their toxicity, volatility, and flammability. To address these challenges, NADES Design has developed innovative green solvents known as Natural Deep Eutectic Solvents (NADES). These 100% natural, biodegradable, and non-volatile biosolvents offer a sustainable alternative, reducing industrial emissions and aligning with international environmental regulations. These green solvents significantly improve the solubility, stability, and bioavailability of plant extracts, making them ideal for the formulation of liquid food supplements. NADES Design is at the forefront of innovation with its pioneering use of Natural Deep Eutectic Solvents (NADES) in the development of NADES GOODNESS, a novel range of liquid food supplements. The NADES GOODNESS product line includes ready-to-use plant-based cocktails tailored for various health benefits, such as nootropic and immune-boosting effects. By utilizing NADES, these supplements ensure higher bioavailability and enhanced efficacy of the active ingredients. This innovative approach not only improves the shelf life and safety of the products but also offers a more sustainable alternative to conventional solvents used in the food and supplement industry.

Our development process involves meticulous *in silico* solvent design and comprehensive optimization of extraction processes. Using advanced technologies like COSMOtherm software, we select and characterize the most effective NADES for specific applications, ensuring regulatory compliance and superior performance. The result is a product line that meets the highest standards of quality and safety, backed by rigorous chemical and biological characterization.

Keywords: Food Supplements, Green Chemistry, Natural Deep Eutectic Solvents (NADES), Plant Extracts, Sustainability.

Corresponding author email: manuela@nades-design.hr

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GREEN EXTRACTION PROCESS OF *SIDERITIS SCARDICA* USING NATURAL DEEP EUTECTIC SOLVENTS FOR COSMETIC APPLICATIONS

Karadendrou M.-A.[1], Tzani A.[1], Karantoni A.[1], Pitterou I.[1], Stavropoulos G.[2], Detsi A.[1]

[1]National Technical University of Athens, School of Chemical Engineering, Zografou Campus, 15780 Athens, Greece

[2]KORRES SA-NATURAL PRODUCTS, 57th Km Athens- Lamia Road, Oinofita Viotia

Abstract

The plant species *Sideritis scardica* is a rich source of bioactive compounds, possessing important bioactivity (such as antioxidant and anti-inflammatory activity) and finds a wide range of applications in the field of cosmetics. The novelty of the present study lies in the use of Natural Deep Eutectic Solvents (NADES) which are a new category of green solvents which derived from natural raw materials and proved to be beneficial for the efficient extraction of bioactive compounds from various natural sources. and the subsequent incorporation of these extracts into cosmetic formulations.

The aim of the present work is the development and optimization of an extraction process of *Sideritis scardica* cultivated at the foothills of the mountain Olympus using NADES as the extraction medium and the incorporation of the optimum NADES-extract "as-obtained" in a cosmetic formulation. The direct use of the optimum NADES-extract is possible because of the task-specific selection of the NADES components to be compatible in the final cosmetic cream formulation. A series of six NADES derived from components such as betaine, glycine, glucose, fructose, glycerol, lactic acid and 1,3-propanediol were synthesized, structurally and physiochemically (in terms of their most important parameters for the studied process) characterized and used as extraction solvents. All extracts were assessed based on their Total Phenolic and Total Flavonoid Content (TPC and TFC respectively). The effect of three factors (extraction time, NADES/water ratio and the solid raw material/solvent ratio) on TPC and TFC values was studied and the process was optimized by Box-Behnken Design of Experiments and statistical analysis of the results. The process was optimized and the TPC and TFC of optimum NADES-extract were compared to the values derived from the conventional extraction using a hydroethanolic solution. Moreover, both extracts were characterized using HPLC analysis. According to the findings of this study, the TPC and TFC values of the NADES-extract were at least 2.4 times higher compared to those obtained from the conventional extraction solvent.

Finally, the optimum NADES-extract was and successfully incorporated in a moisturizing cosmetic cream which, after undergoing 2 freeze-thaw cycles found to maintain its homogeneity and stability.

Keywords: Sideritis scardica, NADES, Green Extraction, Experimental Design

Corresponding author email: atzani@mail.ntua.gr

Acknowledgements: This work was supported by the Alliance of International Science Organizations, project SparkGREEN (ANSO-CR-PP-2022-08)

1. Alternative green solvents and related technologies and processes

Posters

VALORIZATION OF *DESMODIUM CANADENSE* BY EVALUATING ITS ANTIOXIDANT POTENTIAL AND PHYTOCHEMICAL COMPOSITION

***Abbas S.*[1], *Venskutonis P. R.*[2]**

[1,2]*Department of Food Science and Technology, Kaunas University of Technology, Kaunas, Lithuania*
Radvilėn pl. 19, Kaunas LT-50254, Lithuania

Abstract

Desmodium canadense (L.) DC. is often referred to as showy tick trefoil, or Canada tick trefoil, mostly found in central Canada and the northeastern United States. *D. canadense* (L.) leaves are rich in flavonoids; however, their application is limited due to the absence of more comprehensive studies focusing on plant processing. Herein, the lipophilic fraction was recovered with supercritical carbon dioxide (SFE-CO_2) from *D. canadense* leaves collected at different plant vegetation periods (intensive growing, bud formation, beginning, massive, and end of flowering). The SFE-CO_2 residues were consecutively fractionated by pressurized liquid extraction (PLE) with increasing polarity solvents, namely acetone, ethanol, and water. PLE extracts were tested for their antioxidant potential using in vitro chemical (Folin-Ciocalteu (FC), 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS), oxygen radical absorbance capacity (ORAC) and CUPric Reducing Antioxidant Capacity (CUPRAC) assays. Ethanol extracts were the strongest antioxidants with the highest TPC 38.63 mg GAE/g DW at massive flowering, $ABTS^{+\bullet}$, CUPRAC, and ORAC values 149.50±0.21, 108.89±0.53 and 259.98±2.84 equivalent to mg of Trolox per gram Dry Weight of extract (at the same phases) respectively. In general, ethanol extracts of PLE exhibited higher antioxidant capacity values at every growth stage in comparison to extracts with other polarity solvents. Phytochemical analysis of PLE extracts was conducted using ultra-performance liquid chromatography coupled with a quadrupole-time-of-flight (UPLC-Q-TOF) mass spectrometer, leading to the identification of 44 compounds in total. The majority of these compounds were found in acetone and ethanol extracts, while water extracts primarily contained low molecular weight organic acids.

This study emphasizes the potential of high-pressure extraction techniques to isolate antioxidant-rich fractions from *Desmodium canadense* (Canada tick-trefoil) leaves, with diverse applications in the prevention and treatment of chronic diseases. The leaves of *D. canadense* show promise as a valuable source of polyphenolic antioxidants. Future research will aim to provide a more detailed phytochemical characterization of the extracts and explore their use in the development of innovative nutraceuticals and functional foods.

Keywords: Desmodium canadense, antioxidant capacity, supercritical carbon dioxide extraction, pressurized-liquid extraction, phytochemicals

Corresponding author email: sana.abbas@ktu.edu

VIABLILITY OF EXTRACTION METHODS ON ELDERBERRY POMACE

***Dyla B.*[1], Kemény Zs.[2], Vági E.M.[3]**

[1]*Technical University of Denmark, Anker Engelunds Vej 1, 2800 Kongens Lyngby, Denmark*
[2]*Katalin Kővári Innovation Center, Bunge Zrt. Illatos út 38. 1097, Budapest, Hungary*
[3]*Department of Chemical and Environmental Process Engineering, Budapest University of Technology and Economics, Műegyetem rkp. 3, 1111 Budapest, Hungary*

Abstract

Throughout agricultural production, a substantial amount of waste is generated, often discarded or burned. However, agricultural residues frequently contain valuable compounds that can be extracted and repurposed. One such example is the European elderberry (*Sambucus nigra*), whose pomace is rich in bioactive compounds, including antioxidants and lipids. Elderberry has been recognized for its diverse applications in health and wellness, with studies indicating its effectiveness in the prevention and treatment of diabetes, cardiovascular diseases, and cancer. Furthermore, elderberry exhibits potent antiviral properties, contributing to the development of nutraceutical products like Samubucol®, effective against influenza strains. Despite the extensive use of elderberry, the pomace generated during processing remains underutilized. This byproduct is a potential source of valuable compounds like polyunsaturated fatty acids, tocopherols, tocotrienols, and additional anthocyanins. Utilizing elderberry pomace can contribute to waste valorization, offering a sustainable approach to extract high-value nutrients and phytochemicals for use in the food, pharmaceutical, and nutraceutical industries.

Advanced extraction techniques, including ultrasound-assisted extraction (UAE) and supercritical carbon dioxide ($scCO_2$) extraction, or just simple stirred extraction can be employed to isolate these compounds, transforming this low-cost biomass into a valuable resource. These methods were evaluated for their efficiency, energy consumption, and environmental impact on extracting the elderberry waste. The results demonstrated that UAE, using 96% ethanol, achieved the highest extraction yield of 24.9% based on the dry mass of the pomace. Supercritical carbon dioxide extraction ($scCO_2$) also showed promising results, with an extraction yield of 18.07% at 45 MPa and 40°C. $ScCO_2$ extraction, using CO_2 as a solvent, is recognized for its superior solvent regeneration and lower environmental impact, as it allows for quick recycling and minimal solvent loss. While UAE and $scCO_2$ extraction require a higher initial investment than traditional methods, they offer greater productivity and energy efficiency. SFE was the most energy-efficient method in this study, using only 0.02 kWh/g of extract.

The fatty acid analysis of extracts showed very high level of polyunsaturated fatty acid content, with the main constituent (38%) of α-linolenic acid (C18:3 n3).

Overall, this study underscores the feasibility of elderberry pomace valorization using advanced extraction methods, providing a sustainable solution to agricultural waste while yielding high-value bioactive compounds.

Keywords: Elderberry pomace, Extraction, Ultrasound-assisted, Supercritical CO_2, Waste valorization.

Corresponding author email: vagerikamaria@gmail.com, bleddyla@yahoo.com

DEVELOPMENT OF A NOVEL SUSTAINABLE EXTRACTION PROCESS OF NETTLE LEAVES USING NATURAL DEEP EUTECTIC SOLVENTS

Karadendrou M.-A.[1], Nourry E.[1], Bogdanović M. [2], Djukić-Vuković A.[2], Tzani A.[1], Detsi A.[1]

[1]National Technical University of Athens, School of Chemical Engineering, Zografou Campus, 15780 Athens, Greece
[2] University of Belgrade, Faculty of Technology and Metallurgy, Department of Biochemical Engineering and Biotechnology, Karnegijeva 4, 11120 Belgrade, Serbia

Abstract

Nettle (*Urtica dioica* L.) is a wild herbaceous plant that has long been used in traditional medicine to treat various diseases and is a rich source of bioactive compounds with numerous medicinal, nutritional and cosmetic properties. The objective of the present study is the development and optimization of a more environmentally friendly methodology for the extraction of phytochemicals from dry nettle leaves. For the development of the green process, natural deep eutectic solvents (NADES) were used as extraction media. NADES are a new class of green solvents that comprise of two or more naturally-occurring compounds. They have recently gained increased attention as promising extraction solvents due to their numerous advantages, such as high extraction efficiency, stabilization of the obtained extracts and protection of the extracted compounds. In the present work, different NADES were synthesized, structurally characterized and examined for their ability to extract bioactive compounds from dry nettle leaves. The NADES extracts were evaluated regarding their total flavonoid (TFC) and phenolic (TPC) content, as well as their antioxidant activity. The solvent screening indicated that the most potent and at the same time cost-effective extraction solvent was the NADES derived from betaine and glycerol. The extraction methodology was optimized by performing Experimental Design applying a symmetrical three-level Box-Behnken design with selected independent variables the extraction temperature, the NADES-to-water and the solid-to-solvent ratio. The TPC and TFC of the extracts, as well as their DPPH radical scavenging ability were selected as response variables. The phytochemical profile of the optimum NADES-extract was further studied by performing HPLC analysis. The results were compared with an extract derived by extraction using a hydroethanolic solution, revealing a higher amount of the identified bioactive compounds in the NADES extract. In addition to this, the optimum NADES-extract was successfully incorporated in a cosmetic cream formulation and the antioxidant activity and organoleptic characteristics of the cream were determined.

Keywords: Nettle, NADES, Green Extraction, Experimental Design

Corresponding author email: adetsi@chemeng.ntua.gr

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RECOVERY OF POLAR COMPOUNDS FROM POST-SUPERCRITICAL MARIGOLD USING AN ULTRASOUND PROBE

***Gavarić A.*[1], *Vidović S.*[1], *Krivošija S.*[1], *Jokić S.*[2], *Aladić K.*[2]**

[1]*University of Novi Sad*, *Faculty of Technology, Blvd. cara Lazara 1, 21000 Novi Sad, Serbia*

[2]*Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology, Franje Kuhača 20, 31000 Osijek, Croatia*

Abstract

Marigold (*Calendula officinalis* L.) flower extract, particularly obtained through conventional extraction techniques, is widely used as an ingredient in cosmetic products. In addition to liquid extracts, marigold flowers are traditionally utilized in tinctures, ointments, and various herbal preparations, while other parts of the plant remain underutilized. This study focused on these underused fractions, including calyxes and stems, but also petals, as well as a binary mixture of calyxes and petals, and a ternary mixture of stems, calyxes, and petals. Ultrasound-assisted extraction (UAE) was employed using a 50% ethanol solution at a solid/liquid ratio of 1:20 (w/v) with varying amplitudes (20, 60, 100%) and extraction times (10 and 20 min). The maceration was used as a control. The green UAE method targeted the recovery of polar compounds from defatted marigold fractions left after supercritical CO_2 extraction at 300 bar and 40 °C. The HPLC analysis was performed to identify polar compounds present in the 30 obtained ultrasonic extracts and 5 macerates. The most dominant compounds in majority of ultrasonic extracts turned out to be chlorogenic acid and rutin.

Keywords: Marigold, Fractions, Ultrasound extraction, valorization, HPLC

Corresponding author email: cvejina@uns.ac.rs

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RECOVERY OF OLEUROPEIN FROM OLIVE LEAVES USING NATURAL EUTECTIC SOLVENTS AND ULTRASOUND-ASSISTED EXTRACTION

Sánchez-Monedero A.[1], Díaz I.[1], Rodríguez M.[1], González-Miquel M.[1], González E. J.[1]

[1]Dpto. Ingeniería Química Industrial y del Medio Ambiente, ETSI Industriales, Universidad Politécnica de Madrid, C/ José Gutiérrez Abascal 2, Madrid, 28006, Spain

Abstract

Olive trees are the third most cultivated crop in Spain. As a result of this wide harvested area, a large amount of waste is generated every year. Part of this waste consist of olive leaves, which can be utilized to obtain high-value chemicals, such as antioxidants and polyphenolic compounds, through a solid-liquid extraction process. These compounds are highly demanded in the pharmaceutical and food industries. This study aims to valorize olive leaves through solid-liquid extraction using green solvents and advanced technologies to obtain oleuropein, a high-value natural phenolic antioxidant. Thus, three natural eutectic solvents (NAES) formed with three different hydrogen bond acceptors (choline chloride, betaine, and proline) and 1,2-butanediol as hydrogen bond donor in a 1:4 molar ratio were used as solvents for the solid-liquid extraction processes, adding water and ethanol as cosolvents. In addition to the conventional extraction, ultrasound-assisted extraction was also studied for each solvent in order to intensify the process, optimizing the extraction time in both cases. The extraction was quantitatively evaluated using high-performance liquid chromatography and antioxidant capacity measurements. The solvent prepared with 25 % (v/v) proline:1,2-butanediol and 75 % (v/v) ethanol yielded the highest oleuropein content, achieving 40.62 mg / g dry sample with conventional extraction in 30 minutes, and 37.00 mg / g dry sample with ultrasound-assisted extraction in just 1 minute. Overall, the results obtained from the intensified process show similar oleuropein extraction yields, with a significant reduction in both time and energy consumption.

Keywords: Olive; Polyphenols; Extraction; Ultrasound-assisted extraction; Green Solvents; Natural eutectic solvents.

Corresponding author email: ej.gonzalez@upm.es

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APPLICATION OF GREEN SUPRAMOLECULAR SOLVENTS TO THE EXTRACTION OF NATURAL ANTIOXIDANTS FROM OLIVE LEAVES

Sánchez-Monedero A.[1], Díaz I.[1], Rodríguez M.[1], González E. J.[1], González-Miquel M.[1]

[1] Dpto. Ingeniería Química Industrial y del Medio Ambiente, ETSI Industriales, Universidad Politécnica de Madrid, C/ José Gutiérrez Abascal 2, Madrid, 28006, Spain.

Abstract

One of the most important agricultural industries in the Mediterranean basin is olive and olive oil production, using more than 10 million hectares in this area. For this reason, olive industry leads to large quantities of biomass residue derived from olive tree pruning. Olive leaves represent about 25 % of the residue and can constitute a valuable feedstock in biorefineries due to their high content of polyphenolic compounds with antioxidant capacity, which are generally obtained through solid-liquid extraction processes. Such extraction processes usually rely on conventional organic solvents that are toxic and derived from petrochemical sources, which can contribute to environmental pollution and have negative impacts on ecosystems. Thus, this study aims to replace these conventional solvents with supramolecular solvents (SUPRAS), a new generation of green solvents that are low-price and environmentally friendly, to efficiently extract the antioxidants from olive leaves. SUPRAS were prepared using ethanol, water, and five different amphiphiles (two organic acids: octanoic acid and decanoic acid; and three natural eutectic solvents: octanoic acid: decanoic acid [1:1], menthol: octanoic acid [1:1], and menthol: decanoic acid [1:1]). The extraction was quantitatively assessed using high-performance liquid chromatography measurements. The octanoic acid-based SUPRAS extracted the highest polyphenol content, yielding up to 68.67 mg / g dry sample. Additionally, the SUPRAS solvents were characterized by measuring their chemical composition, polarity, phase diagrams, and phase ratios. Lastly, the stability of the polyphenolic extracts was evaluated under various temperature and light conditions to monitor antioxidant degradation over time.

Keywords: Olive; Polyphenols; Extraction; Supramolecular solvents; Green Solvents; Natural eutectic solvents.

Corresponding author email: maria.gonzalezmiquel@upm.es

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EXPLORING NATURAL DEEP EUTECTIC SOLVENTS AS EFFECTIVE INHIBITORS OF THE ENZYME MUSHROOM TYROSINASE

***Karadendrou M. A.*[1], *Triantafyllopoulou A. A.*[1], *Tzani A.*[1], *Detsi A.*[1]**

[1]*Laboratory of Organic Chemistry, School of Chemical Engineering, National Technical, University of Athens, Zografou Campus, Heroon Polytechniou 9, 15780 Athens, Greece*

Tyrosinase is a copper-containing enzyme present in mammals, plants, bacteria and fungi and catalyzes oxidation reactions of both monophenolic and diphenolic compounds. In nature, tyrosinase plays a crucial role in the melanogenesis and enzymatic browning of fruits and vegetables. However, abnormal activity of this enzyme can lead to problems such as hyperpigmentation and melanoma. In recent years the interest of the research community is focusing on the discovery of potent tyrosinase inhibitors that could be used and incorporated in pharmaceutical, cosmetic and food formulations.

In this project, an attempt to inhibit mushroom tyrosinase activity using Natural Deep Eutectic Solvents (NADES) is presented. NADES are a new class of green solvents that comprise of naturally-occurring compounds, such as polyols, carboxylic acids and amino acids, that interact with each other via intramolecular hydrogen bonds, leading to the formation of a eutectic mixture with melting point significantly lower than that of the individual compounds. NADES have emerged as promising solvents since they are non-volatile, non-flammable, biodegradable and can be task-specifically designed to meet the demands of each application.

In this context, carboxylic acid-based NADES were synthesized by selecting their components in such a way that they are biocompatible and safe to use for applications in cosmetic and pharmaceutical formulations. The NADES were structurally characterized via ^{1}H NMR, while four of their physicochemical properties were measured (pH, viscosity, polarity, water content). The synthesized NADES, as well as their components individually, were evaluated regarding their ability to inhibit mushroom tyrosinase activity. The results showed that the NADES containing choline chloride and carboxylic acids as components, show significantly low IC_{50} values from 3.8 to 7.9 μg/mL, rendering the tested NADES as promising tyrosinase inhibitors. Furthermore, the inhibition type (competitive, uncompetitive, non-competitive) of selected NADES was investigated revealing that both the hydrogen bond donor and the hydrogen bond acceptor that participate in the formation of the NADES, affect the inhibition mechanism.

Keywords: Natural Deep Eutectic Solvents, Mushroom Tyrosinase, Enzyme Inhibition.

Corresponding author email: mariannakaradendrou@mail.ntua.gr

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ADVANCING THE CIRCULAR ECONOMY IN THE TEXTILE INDUSTRY: DECOLORIZING COTTON WITH IONIC LIQUIDS

Martínez-Rico Ó., Domínguez Á., González B*

Universidad de Vigo, Department of Chemical Engineering, Vigo, 36310, Spain

Abstract

In the face of escalating climate change and global population growth, the textile industry faces the dual challenges of depleting water resources and the increasing scarcity of essential materials. Traditionally, the industry has followed a linear model of extracting raw materials, processing them, and releasing final products into the market. This approach, however, generates substantial waste, much of which ends up in landfills due to inefficient recycling processes, contributing to serious environmental consequences.

Recent efforts aim to shift the textile sector towards a circular, zero-waste economy, with a particular focus on cotton recycling. Countries like the USA and the UK collectively generate 15.1 and 1.7 million tons of cotton waste annually, respectively. Despite relatively higher recycling rates—averaging around 20%—there remains an urgent need for more sustainable methods to improve cotton recycling. This work explores the development of eco-friendly techniques for dye removal from cotton, highlighting the critical role of Ionic Liquids in promoting sustainable practices within the textile industry.

References:

[1] Yousef, S., Tatariants, M., Tichonovas, M., Kliucininkas, L., Lukošiūtė, S. I., & Yan, L. (2020). Sustainable green technology for recovery of cotton fibers and polyester from textile waste. *Journal of Cleaner Production*, *254*, 120078

Corresponding author email: bgp@uvigo.es

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SOLUBILITY OF QUERCETIN AND TRANS-PICEID IN METHANOL, ETHANOL, MEK AND MIXED SOLVENTS

Montenegro I., González B., Domínguez A., Gómez E.

Chemical Engineering Department, University of Vigo, Vigo, Spain

Abstract

The grape pomace is rich in bioactive compounds that have attracted considerable interest due to their potential nutritional and therapeutic value as antioxidant, antitumor, anti-aging, anti-microbial or anti-inflammatory. Approximately 50% of the polyphenols present in the grape remains in the waste after maceration process, thus grape pomace can be exploited as a valuable source of these compounds. In order to explore the selective extraction of these compounds it is necessary to obtain solubility data of these antioxidant compounds in environmentally friendly solvents since literature data are scarce.

Quercetin and trans-piceid, have been selected due to their presence in winemaking waste and their industrial interest. The solvents have been chosen based on their polarity and green character. Due to the lack of physical property data of these compounds, the solubility of quercetin and trans-piceid in methanol, ethanol and methyl ethyl ketone (MEK) and mixed solvents methanol or ethanol + MEK were determined.

The solubility of quercetin in pure solvents were in the following order: MEK > ethanol > methanol, and for trans-piceid the order obtained was: methanol > ethanol > MEK. A maximum of solubility of quercetin in the binary systems ethanol + MEK and methanol +MEK was observed near 0.7 and 0.8 mole fractions in MEK, respectively, and the highest solubility was achieved in the system composed of ethanol. The solubility of trans-piceid in ethanol + MEK and methanol + MEK presented a maximum for 0.4 and 0.2 mole fractions in MEK, respectively, and in this case the highest solubility was obtained for methanol + MEK system.

One of the most interesting conclusion that can be drawn from this work is that if the goal is to selectively extract quercetin from a mixture containing both quercetin and trans-piceid, pure MEK as solvent would be an excellent option.

Keywords: quercetin, trans-piceid, selectivity, solubility.

Corresponding author email: bgp@uvigo.es

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OPTIMIZATION OF ULTRASOUND-ASSISTED EXTRACTION OF HYPOCHOLESTEROLEMIC COMPOUNDS FROM *AGARICUS BISPORUS* BY-PRODUCTS

Xavier, V.[1,2], Roriz, C.[1], Ueda, J.M.[1], Prieto, M.A.[2], A.O.S. Jorge[3], Chamorro, F.[3], Carocho, M.[1], Calhelha, R.C.[1], Heleno S.A.[1]

[1]CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[2]Grupo de Nutrición y Bromatología, Departamento de Química Analítica y Alimentaria

Abstract

The Mush4Chol project explores mushroom bioresidues as sources of hypocholesterolemic compounds, including ergosterol and statins, which inhibit cholesterol synthesis and absorption. This research supports cardiovascular health and addresses environmental challenges by incorporating extracts into functional foods and nutraceuticals. The study optimized ultrasound-assisted extraction to maximize the recovery of ergosterol and statins from *Agaricus bisporus* (Cremini/Baby Portobello) bioresidues. A central composite design evaluated the effects of extraction time, solvent composition, and ultrasonic power. Response surface methodology tested 25 conditions, and HPLC-UV analysis identified and quantified the target compounds. Pravastatin and ergosterol were detected in all extracts. The model showed maximum pravastatin yield using 50% methanol, while ergosterol concentration peaked with 100% ethanol. These conditions highlight the differing solubility and extraction dynamics of the compounds. To optimize the use of a green solvent, ethanol, the process was simulated, and the model predicted conditions for extracting both compounds in a single process. The model indicated that 100% ethanol could recover 84% of pravastatin and 91% of ergosterol, close to their individual optimum yields. This combined extraction approach offers a practical solution, achieving high recovery rates while maintaining efficiency with a green solvent. The findings highlight the potential of *A. bisporus* bioresidues as a sustainable source of hypocholesterolemic compounds and demonstrate the promise of mushroom-derived compounds for innovative, health-focused solutions in the food and nutraceutical industries.

Keywords: hypocholesterolemic agents, mushrooms, residues, valorization, circular economy.

Corresponding author email: sheleno@ipb.pt
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PHYTOCHEMICAL PROFILE OF *ULVA LACTUCA* FROM THE ADRIATIC SEA

***Jokić S.*[1], Radman S.[2], Jerković I.[2], Aladić K.[1], Flanjak I.[1], Babić J.[1], Pavičić E.[1], Šubarić D.[1], Čoz-Rakovac R.[3]**

[1]*Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, Franje Kuhača 18, 31000 Osijek, Croatia;*
[2]*Faculty of Chemistry and Technology, University of Split, Ruđera Boškovića 35, 21000 Split, Croatia;*
[3]*Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia*

This extensive chemical profiling of *Ulva lactuca* from the Adriatic Sea revealed the presence of various compounds, some of which have bioactive properties. HS-SPME/GC-MS and analysis of the hydrodistillate revealed the presence of various volatile organic compounds such as various aldehydes, benzyl alcohol, (Z,Z,Z)-hexadeca-7,10,13-trienal and hexadecanoic acid, all of which are used in the cosmetics industry. The predominance of saturated fatty acids, especially palmitic acid, together with a favourable ratio of n-6/n-3 polyunsaturated fatty acids, makes this alga a valuable component of a balanced diet. Major non-volatile compounds in *U. lactuca* were identified using high-performance liquid chromatography–high-resolution mass spectrometry with electrospray ionization (UHPLC-ESI–HRMS) in both positive (ESI+) and negative (ESI-) mode. Hexadecasphinganine was identified as the most abundant compound followed by azelaic acid. Among phenolics, 5-sulfosalicylic acid was the most abundant, followed by 4-hydroxybenzoic acid-4-O-sulphate, vanillic acid 4-sulfate and 4-hydroxybenzoic acid. Pheophytin a, hydroxypheophytin a, and pheophorbide a were the most abundant among pigment derivatives.
Overall, *U. lactuca* is a promising candidate for future food and pharmaceutical applications. The knowledge gained in this study paves the way for further research into its health benefits, novel applications, and commercial viability.

Keywords: Ulva lactuca, bioprospecting, Adriatic sea, volatiles, UHPLC-ESI–HRMS

Corresponding author email: sjokic@ptfos.hr

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DEVELOPMENT OF A GREEN EXTRACTION PROCESS FROM RESIDUES OF ASSYRTIKO WINE PRODUCTION FOR COSMETIC APPLICATIONS

***Kalafateli S.*[1], *Freri A.-A.*[1], *Tzani A.*[1], *Stavropoulos G.*[2], *Detsi A.*[1]**

[1]*Laboratory of Organic Chemistry, School of Chemical Engineering, National Technical University of Athens, Zografou Campus, 15780 Athens, Greece*
[2]*KORRES SA-NATURAL PRODUCTS, 57th Km Athens-Lamia Road, Oinofita Viotia, Greece*

Abstract

The white Greek variety "Assyrtiko" of *Vitis vinifera* is a worldwide-famous grape variety indigenous in the island of Santorini, where it has been cultivated for hundreds of years. The residues of wine production are rich in polyphenols with significant bioactivity, therefore the extraction of these compounds from wineries' waste is a promising approach to valorize this biomass. Natural Deep Eutectic Solvents (NaDESs) are mixtures of two or more solid or liquid ingredients of natural origin, liquid at ambient temperature, which possess ability to dissolve a plethora of compounds. This makes them promising sustainable alternatives to traditional organic solvents in extraction processes.

The aim of the present work is the development and optimization of an extraction process of Assyrtiko wine production waste as feedstock, using NaDES as the extraction medium. The resulting extracts were incorporated "as-obtained" in an innovative cosmetic formulation, because the components of the NaDES were task-specifically selected to be compatible with the final formulation. A series of four NaDESs, containing betaine as the hydrogen bond acceptor and glycerol, lactic acid and 1,3-propanediol as hydrogen bond donors, were synthesized and characterized in terms of their pH and polarity, and used as extraction solvents. All extracts were assessed based on their Total Phenolic (TPC) and Total Flavonoid Content (TFC). The effect of three factors (extraction time, % w/w NaDES in the final NADES-water system and solid raw material/solvent ratio) on TPC and TFC values was studied and the process was optimized by Box Behnken Design of Experiment and statistical analysis of the results. The extract with the best profile, showing maximum contents of TPC (50.8 mg GAE/g) and TFC (48.9 mg CE/g), was obtained using the NaDES comprising of betaine and 1,3-propanediol and exhibited significant ability to scavenge the free radical DPPH (IC_{50} 13.6 mg/ml). This extract was successfully incorporated in a moisturizing cosmetic cream which, after undergoing three freeze-thaw cycles maintains its homogeneity and stability.

Keywords: Assyrtiko, residues, NaDESs, extraction, cosmetics

Corresponding author email: stellakalafateli@gmail.com

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EXTRACTION OF PHENOLICS FROM GRAPE SKIN AND ROSEHIP FRUIT

Knez Marevci M. [1,2], ***Žitek T.*** [1,2], ***Knez Ž.*** [1,2]

[1]*Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova 17, SI-2000 Maribor, Slovenia*
[2]*Faculty of Medicine, University of Maribor, Taborska 8, SI-2000 Maribor, Slovenia*

Abstract

The identification and development of phenolic compounds or extracts from different plants has become a significant area of food, health- and medical-related research in the past decade. Nonetheless, most of the compounds are extracted using conventional solvent extraction methods. Modernized extraction methods, innovative formulation technologies and advanced analytical techniques such as high-performance liquid chromatography, thin layer chromatography and gas chromatography are used intensively investigated in order to obtain product with a lower environmental impact. Particular attention is paid to the preservation of useful biological components through formulations that add value to natural products. The present investigation concerns solid liquid extraction from red and white grapes skin and the rosehip (*Rosa canina*) to attain extracts with a high content of phenolic compounds. Conventional extraction techniques and extraction with supercritical fluids (SCFs) have been carried out and the impact of extraction technique and experimental parameters such as time, pressure, temperature, and solvent mixture were examined. The highest content of total phenolics was determined in the extract from the white grape skin, macerated with MeOH (26.7 mg GA/g extract), and similar, 25.6 mg GA/g extract in the MeOH extract attained by Soxhlet. Ellagic acid (0.650 mg/100 g extract), catechin (0.164 mg/100 g extract), gallic acid (0.133 mg/100 g extract) as well as caffeic acid (0.038 mg/100 g extract) are the major compounds present in the rosehip extracts attained by maceration using MeOH as solvent. Novel tools involving supercritical fluids as processing media allow extraction of very pure, high-value products from materials which otherwise would be considered by-products or waste and sold cheaply, or simply disposed of. Such processing concepts promote reuse of residues from food industry.

Keywords: Antioxidants, Conventional extraction; Supercritical fluid extraction; Chromatography.

Corresponding author email: masa.knez@um.si

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AN ALGINATE-SUPPORTED NADES SYSTEM FOR SUSTAINABLE CATALYSIS

Neofotistos S.*[1], Tsitsimpis V.[1], Tzani A.[1], Detsi A.[1]

[1] School of Chemical Engineering, National Technical University of Athens, 9 Heroon Polytechniou Str., 15780, Athens, Greece

Abstract

Sodium alginate is a naturally derived biopolymer that its use is well established in food and pharmaceutical industries and is recently emerging as a versatile material in catalytic applications. Deep Eutectic Solvents (DES) are eutectic systems, formed between at least one Hydrogen Bond Donor (HBD) and one Hydrogen Bond Acceptor (HBA). When the HBD and HBA are selected from naturally occurring compounds, the eutectic system is characterized as Natural Deep Eutectic Solvent (NADES). NADES have a wide variety of applications such as extractions solvents , solvents and catalysts for organic reactions and many more.

Our research group introduces an innovative approach which exploits the unique properties of this biopolymeric matrix to create a supported NADES catalytic system. This system is resourcefully formulated into catalytic beads which offer high customizability and ease of handling. Incorporating the crosslinking ability of specific NADES, these beads provide structural stability, whilst simultaneously, the integrated NADES serves as active catalyst for the promotion of esterification and transesterification reactions. Key features of our proposed system include the biodegradability of the polymeric matrix, low catalyst loading and potential reusability. These aspects, cumulatively align with the growing demand for environmentally friendly solutions in chemical transformations, providing a path toward greener future.

Sustainable Chemistry, Green Processes, Catalytic Alginate beads, Experimental Design, Natural Deep Eutectic Solvents

Corresponding author email: adetsi@chemeng.ntua.gr

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RATIONAL DESIGN OF NATURAL DEEP EUTECTIC SOLVENTS FOR LIFE SINCE APPLICATIONS

Cvjetko Bubalo M.[1], Radošević K.[1], Panić M.[1,2], Radović M., Bagović, M. Logarušić, Damjanović, A., Radojčić Redovniković I.[1]

[1] University of Zagreb, Faculty of Food Technology and Biotechnology, Perottijeva 6, 10 000 Zagreb, Croatia

[2] Nades Design Ltd., Borongajska cesta 83H, 10 000 Zagreb, Croatia

Abstract

Natural deep eutectic solvents (NADES) provide an environmentally friendly and sustainable alternative to traditional organic solvents, aligning with green chemistry principles while being highly customizable for various life science applications. However, identifying the optimal NADES for specific tasks can be complex and unpredictable. This process involves not only selecting the right combination of components and molar ratios but also understanding the key physical, thermal, chemical, and biological properties of the solvent. Traditional methods of identifying NADES often rely on time-consuming empirical approaches and trial-and-error, which fail to thoroughly explore structure-activity relationships. Recently, COSMO-RS software has been proposed as a tool for the rational design of NADES. This predictive model calculates thermodynamic properties and phase equilibrium, offering a systematic approach to developing NADES with tailored properties. It can also be used for solubility screening of target compounds, reducing the need for extensive experimental testing. By strategically selecting and combining natural components, the rational design of NADES aims to achieve specific characteristics and functionalities for various applications. Herein, examples of rationally design of NADES for the extraction of biologically active compounds, enzyme-catalyzed reactions, and the stabilization of macromolecules such as proteins will be presented.

Keywords: Natural deep eutectic solvents, rational design, COSMO-RS, biocatalysis, extraction

Corresponding author email: irredovnikovic@pbf.hr

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FRUIT PEEL VALORIZATION THROUGH SUSTAINABLE GREEN SOLVENT TECHNOLOGIES

Travičić V.[1], Cvanić T.[1], Vučetić A.[1], Vulić J.[1], Ćetković G.[1]

[1]Faculty of Technology Novi Sad, University of Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia

Abstract

The growing generation of food and agricultural waste worldwide presents a serious environmental challenge, contributing to the depletion of limited landfill space and irreversible problems such as global warming. To address these concerns, recent research has focused on waste valorization and value-added trends. One key area of interest is the extraction of bioactive compounds. This process necessitates the design of innovative, eco-friendly methods that can deliver high yields of bioactive molecules while minimizing the use of toxic and harmful solvents. Accordingly, the present study aimed to compare two green solvent technologies (supramolecular solvent-based extraction – SUPRAS and cloud point extraction – CPE) to extract valuable bioactives from peels of four fruits, i.e. tangerine, orange, kiwano, and citron peels. SUPRAS made up of octanoic acid, ethanol, and acidified water (pH ~ 3), while CPE include micellar solution of non-ionic surfactant (Tween 80). Several factors were evaluated for their effect on extraction efficiency, such as bioactive profiles of polyphenols, carotenoids and vitamin C, antioxidant activity by three methods, and environmental impact. Both SUPRAS and CPE yielded the higher levels of carotenoids when compared to extracts obtained using conventional techniques with water and a water:ethanol (64:36, v/v) mixture. The SUPRAS extracts demonstrated the highest antioxidant activity, and tangerine peel extracts showing the greatest potential among the tested samples. The specific antioxidant values were as follows: ABTS: 17.22 mM TEAC/100g, RP: 0.96 mM TEAC/100g, and DPPH: 1.27 mM TEAC/100g. Replacing harmful solvents with renewable alternatives can enhance the extraction process by making it safer, more efficient, and economically viable. As research advances, combining green solvents with cutting-edge extraction techniques holds great promise for the future of bioactives extraction and the sustainability of various industries. The environmental impact and practicality of this process were favorably assessed using the Eco-Scale and BAGI metrics. These findings offer important perspectives on the revalorization of fruit by-products.

Keywords: fruit by-products,antioxidants, green extraction, SUPRAS extraction, Cloud point extraction

Corresponding author email: vanjaseregelj@tf.uns.ac.rs

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VIABLILITY OF EXTRACTION METHODS ON ELDERBERRY POMACE

***Dyla B.*[1], Kemény Zs.[2], Vági E.M.[3]**

[1]*Technical University of Denmark, Anker Engelunds Vej 1, 2800 Kongens Lyngby, Denmark*
[2]*Katalin Kővári Innovation Center, Bunge Zrt. Illatos út 38. 1097, Budapest, Hungary*
[3]*Department of Chemical and Environmental Process Engineering, Budapest University of Technology and Economics, Műegyetem rkp. 3, 1111 Budapest, Hungary*

Abstract

Throughout agricultural production, a substantial amount of waste is generated, often discarded or burned. However, agricultural residues frequently contain valuable compounds that can be extracted and repurposed. One such example is the European elderberry (*Sambucus nigra*), whose pomace is rich in bioactive compounds, including antioxidants and lipids. Elderberry has been recognized for its diverse applications in health and wellness, with studies indicating its effectiveness in the prevention and treatment of diabetes, cardiovascular diseases, and cancer. Furthermore, elderberry exhibits potent antiviral properties, contributing to the development of nutraceutical products like Samubucol®, effective against influenza strains. Despite the extensive use of elderberry, the pomace generated during processing remains underutilized. This byproduct is a potential source of valuable compounds like polyunsaturated fatty acids, tocopherols, tocotrienols, and additional anthocyanins. Utilizing elderberry pomace can contribute to waste valorization, offering a sustainable approach to extract high-value nutrients and phytochemicals for use in the food, pharmaceutical, and nutraceutical industries.

Advanced extraction techniques, including ultrasound-assisted extraction (UAE) and supercritical carbon dioxide ($scCO_2$) extraction, or just simple stirred extraction can be employed to isolate these compounds, transforming this low-cost biomass into a valuable resource. These methods were evaluated for their efficiency, energy consumption, and environmental impact on extracting the elderberry waste. The results demonstrated that UAE, using 96% ethanol, achieved the highest extraction yield of 24.9% based on the dry mass of the pomace. Supercritical carbon dioxide extraction ($scCO_2$) also showed promising results, with an extraction yield of 18.07% at 45 MPa and 40°C. $ScCO_2$ extraction, using CO_2 as a solvent, is recognized for its superior solvent regeneration and lower environmental impact, as it allows for quick recycling and minimal solvent loss. While UAE and $scCO_2$ extraction require a higher initial investment than traditional methods, they offer greater productivity and energy efficiency. SFE was the most energy-efficient method in this study, using only 0.02 kWh/g of extract.

The fatty acid analysis of extracts showed very high level of polyunsaturated fatty acid content, with the main constituent (38%) of α-linolenic acid (C18:3 n3).

Overall, this study underscores the feasibility of elderberry pomace valorization using advanced extraction methods, providing a sustainable solution to agricultural waste while yielding high-value bioactive compounds.

Keywords: Elderberry pomace, Extraction, Ultrasound-assisted, Supercritical CO_2, Waste valorization.

Corresponding author email: vagerikamaria@gmail.com, bleddyla@yahoo.com

DEVELOPMENT OF AN EFFECTIVE METHOD FOR DECONTAMINATING PLASTIC WASTE USING A SUPERCRITICAL FLUID

Wala Zoghlami W. [1,2], ***Isaline Lhoste I.*** [2], ***Karine Seaudeau-Pirouley K.*** [2], ***Supiot P.*** [1], ***Maschke U.*** [1]

[1] *Unité Matériaux et Transformations (UMET), UMR 8207, CNRS, INRAE, Université de Lille, 59000 Lille, France*

[2] *Innovation Fluides Supercritiques (IFS), 26000 Valence, France*

Abstract

This project addresses the management of plastic waste, with a particular emphasis on polymers containing brominated flame retardants (BFRs). The recycling of plastic waste from electrical and electronic equipment containing BFRs presents a number of challenges, the most significant of which is the recent introduction of regulations pertaining to the environmental toxicity and bioaccumulation of these substances.

The goal of this project is to develop a sustainable process for decontaminating these plastics, allowing for their integration and reuse in the recycling process. The proposed process has been proven effective for decontaminating plastics on a laboratory or pilot scale using supercritical fluid treatment with supercritical carbon dioxide (sc-CO_2).

The supercritical carbon dioxide (sc-CO_2) solvent is non-toxic and exhibits intermediate properties between liquids and gases, which makes it highly diffusible and soluble.

The study will apply the aforementioned technique to polymer/BFR model systems, with subsequent characterization of the resulting effects through comparison of the properties of the initial and treated samples. A variety of analytical techniques will be used to assess the polymer's evolution and the presence of contaminants in parallel.

Keywords: Supercritical CO_2 extraction, Decontamination, Brominated flame retardants, Polymers, WEEE.

Corresponding author email: wala.zoghlami.etu@univ-lille.fr

2. Green strategy embedded in biotechnology: biomass, bioenergy, and biobased products

Oral presentations

ENHANCING CYCLODEXTRIN GLYCOSYLTRANSFERASE PERFORMANCE WITH METAL-ORGANIC FRAMEWORKS

***Ogunbadejo B. A.*[1], *Al-Zuhair S.*[1]**

[1]*Chemical and Petroleum Engineering, UAE University, 15551 AlAin, United Arab Emirates*

Abstract

The significance of cyclodextrins (CDs) and their derivatives in various industries have been increasing, driving a crucial demand for their effective production. The conventional CD production method, which relies on starch conversion activated by cyclodextrin glycosyltransferase (CGTase), faces significant economic challenges due to high enzyme cost. To overcome this, recent studies have explored the immobilization of CGTase on various supports to enhance enzyme stability and reusability. Metal-organic frameworks (MOFs) have emerged as promising alternatives to conventional supports, showing potential for improved enzyme performance. In our study, we investigated the effectiveness of MIL-101 MOF as compared to conventional support such as zeolite Y. MIL-101 was found to offer a higher adsorption capacity, resulting in superior enzyme activity, stability and selectivity. To overcome the diffusional limitations of the large starch substrate, two-dimensional MOF, namely Ca-TMA, was tested and its performance was compared to graphene nanoplatelets (GNP). Ca-TMA provided better specific activity and lower conformational changes in CGTase, but the GNP demonstrated better reusability. To combine the stability with reduced diffusion limitation, a hierarchical copper-based MOF (H-Cu-BTC), was prepared to have mesopores. When tested as a support for CGTase, H-Cu-BTC outperformed its microporous counterpart (Cu-BTC) in enzyme adsorption and stability, maintaining higher enzyme activity over multiple cycles. The good performance of CGTase@ H-Cu-BTC was confirmed using real waste starchy materials. The results of our work highlight the advantages of using MOFs for CGTase immobilization, providing enhanced enzyme stability, higher adsorption capacity, and better reusability. These findings suggest that MOFs, especially those with hierarchical structures, could significantly improve the efficiency and economic feasibility of CD production processes by optimizing enzyme performance and reducing operational costs.

Keywords: Cyclodextrins, Cyclodextrin glycosyltransferase, Metal Organic Framework, two-dimensional MOF, Mesoporous MOF

Corresponding author email: s.alzuhair@uaeu.ac.ae

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BIO-HYDROGEN PRODUCTION THROUGH SEMI-CONTINUOUS DARK FERMENTATION OF FOOD WASTE AND WASTE ACTIVATED SLUDGE

Biasiolo M.[1], Mazzolini F.[1], Tassinato G.[2], Cavinato C.[1]

[1] Università Ca' Foscari Venezia, via Torino 155, 30172 Venezia, Italia
[2] Green Propulsion Laboratory, VERITAS spa., via della Geologia 31, 30176 Fusina, Italia

Abstract

Hydrogen has emerged as a promising tool to guide the transition from a fossil-based to a zero-carbon society. However, current production methods are highly carbon-intensive, undermining the possibility of using hydrogen as a clean energy vector. This has resulted in a growing interest in developing low-carbon and zero-carbon alternatives. Among them, hydrogen production via electrolysis using renewable energy sources (i.e., green hydrogen) and via biological processes (i.e., bio-hydrogen) stands out for their low carbon footprint. Biological processes, in particular, offer several advantages, including the mild operative conditions of the process, the possibility to utilize biomass or organic waste as feedstocks, and the possibility to be carbon negative when the process is coupled with carbon capture, utilization, and storage (CCUS) systems. Food waste can serve as a valid feedstock for biological hydrogen production, being one of the most abundant types of organic waste generated worldwide, widely available across different regions, and characterized by a chemical and physical composition well suited for Dark Fermentation processes. In this study, the food waste (FW) collected from a municipal fruit and vegetable market was fermented together with waste activated sludge (WAS) in a semi-continuous dark-fermentation process. The test was carried out in a 4 L lab-scale fermenter kept at 37.0 ± 0.6 °C and mixed continuously at 14 rpm. The test lasted 43 d and was fed with a 20:80 FW:WAS mixture (on fresh matter basis) with an OLR of 12.0 kg_{TVS} m^{-3} d^{-1} and a HRT of 3.1 d. The pH of the system was recorded continuously and automatically adjusted at 5.5. During the stability phase, reached after 3 weeks of operation, the process resulted in 143 ± 20 and 54 ± 10 NL kg_{TVS}^{-1}, as average specific gas (SGP) and hydrogen (SHP) production, respectively. The produced gas comprised 37.5 ± 2.5 % hydrogen, with the remaining part composed of CO_2 and a residual amount of methane (< 3 %). These results highlight the potential of food waste in developing sustainable alternative routes for hydrogen production.

Keywords: bio-hydrogen, dark fermentation, food waste, waste activated sludge

Corresponding author email: cavinato@unive.it

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PROCESS INTEGRATION OF CATALYTIC AND BIOLOGICAL CO_2 METHANATION FOR POWER TO GAS APPLICATIONS

Colelli L.[1], Verdone N.[1], Bassano C.[2], Vilardi G.[1]

[1] "Sapienza" University of Rome, Dept. of Chemical Engineering Materials Environment, via Eudossiana 18, 00184, Rome, Italy
[2] ENEA - Italian Agency for New Technologies, Energy and Sustainable Economic Development, Via Anguillarese 301 - 00123 Rome, ITALY

Abstract

To mitigate the effects of global warming and enhance energy independence, nations worldwide are urged to significantly increase the proportion of energy derived from renewable sources in their energy portfolios. However, the variable nature of renewable energy generation inevitably leads to discrepancies between energy supply and demand. In this context, this study investigates the integration of catalytic and biological CO_2 methanation processes within the framework of Power-to-Gas (PtG) applications, which is a key technology for energy storage and decarbonization. The PtG concept involves converting surplus renewable electricity into synthetic methane (CH_4) by utilizing CO_2 and green hydrogen (H_2) produced via water electrolysis. In this hybrid approach, the catalytic process, conducted through the Sabatier reaction, provides a rapid and efficient conversion of CO_2 to CH_4 at elevated temperatures using metal-based catalysts (Ni and Ru), while the biological process harnesses methanogenic microorganisms (methanogenic archaea) at lower temperatures for CO_2 reduction. The integration of these two methods aims to combine the high conversion efficiency of catalytic methanation with the operational flexibility and mild conditions of biological methanation. Catalytic methanation swiftly converts CO_2 and H_2 at high temperatures, whereas biological methanation offers advantages in terms of tolerance to impurities and the capacity to operate under variable gas compositions. By merging these processes, the overall system can achieve enhanced energy efficiency and flexibility, enabling the PtG system to respond effectively to fluctuations in renewable energy supply. This integrated system holds promise for optimizing methane yields, reducing energy consumption, and increasing process stability, making it a viable approach for large-scale CO_2 recycling and renewable energy storage. The present study highlights key challenges in process integration, such as optimizing reactor design, synchronizing operational conditions, and balancing the catalytic and biological stages for maximum efficiency. These findings contribute to the advancement of Power-to-Gas technologies, addressing both energy storage needs and carbon capture solutions for a sustainable energy future. Analyses are conducted using the Aspen Plus simulation environment to evaluate both the catalytic and biological aspects of the process. Furthermore, the process parameters that affect the system are thoroughly examined, including the type of reactor and various operating conditions. Throughout the analysis, explanations are provided for the performance variations noted in the scientific literature, identifying technical challenges and proposing potential solutions to address these limitations.

Keywords: catalytic, biological, integration, CO_2, methanation

Corresponding author email: leonardo.colelli@uniroma1.it

BIOFUELS PRODUCTION BY GROWING ENERGY CROPS ON CONTAMINATED LANDS THE GOLD PROJECT

Alexopoulou E.

CRES, 19th Km Marathonos Avenue, 19009, Pikermi Attikis, Greece

Abstract

Lignocellulosic energy crops have been proven to be tolerant to the majority of metal(loid)s, and therefore they can grow on contaminated lands for biofuels, avoiding the food vs fuel competition, and turning a problem into an opportunity: biofuel production and land decontamination that is the aim of GOLD project (2021-25, www.gold-h2020.eu). This research project is mainly built on three pillars. On the first pillar the optimization of selected high-yielding lignocellulosic energy crops (miscanthus, switchgrass, biomass sorghum and industrial hemp) for phytoremediation purposes are being addressed in two continents: in Europe (Greece, Italy, France, Poland) and in Asia (India and China). The optimization targets are: a) increasing the potential remediation performance of the selected energy crops by improving their biomass production and, thus, their final bioaccumulation and b) reducing the soil contaminants levels either via uptake (inorganic contaminants) or degradation (organic contaminants) by proposing appropriate management practices (plant-associated microorganisms and a variety of bio-stimulants). Pilot small-scale field trials have been established in 2022 (0.5 ha each; three growing cycles have been completed) having dual-fold purposes: the application of the best-performing management practices for phytoremediation, and the feedstock production that will feed the conversion processes. The use of biomass harvested from existing contaminated sites -and not artificially contaminated- is crucial for gaining reliable results from the conversion methods. On the second pillar, the biofuel production is being accomplished by two thermochemical conversion routes. In the first route, the contaminated feedstock is being pre-treated (by Torwash, torrefaction or low-temperature pyrolysis) and gasified at high temperatures securing the ash heavy metals in a condensed vitrified slag. The produced syngas, after cleaning, will subsequently be fermented to final liquid biofuels. The second route consists of a pyrolysis-based solution with the subsequent upgrade of the pyrolysis products to refinery-compatible intermediates and Fisher-Tropsch-fuels. In both routes the produced liquid biofuels will be clean and the contaminants are being collected in concentrated form. In the third pillar, an integrated sustainability assessment is being carried out and a specific model is being developed for selected value-chains, so as to bridge the gap between phytoremediation strategies and clean biofuel production. Mapping in details the contaminated sites and analyzing the decontamination strategies in terms of further replication at EU level. Spatially explicit models have been applied to estimate the potentials, at EU level, of the contaminated areas that could be remediated, the feedstock quantities that could be produced, as well as, the relevant quantities of biofuel production.

Keywords: biofuels, phytoremediation, energy crops, biomass

Corresponding author email: ealex@cres.gr

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MICROALGAE-BASED DIRECT AIR CAPTURE SOLUTIONS FOR CO_2 EMISSIONS MANAGEMENT IN DEVELOPING MEGACITIES

Dayanath W. M. S.[1,2], Ilankoon I. M. S. K.[1,2], Chong M. N.[1], Foo, S. C.[3]

[1]School of Engineering, Monash University Malaysia, Jalan Lagoon Selatan, Bandar Sunway, Selangor Darul Ehsan 47500, Malaysia
[2]Waste and Critical Metals Sustainability Research Group, School of Engineering, Monash University Malaysia, Jalan Lagoon Selatan, Bandar Sunway, Selangor Darul Ehsan 47500, Malaysia
[3]School of Science, Monash University Malaysia, Jalan Lagoon Selatan, Bandar Sunway, Selangor Darul Ehsan 47500, Malaysia

Abstract

Urbanisation and climate change are critical challenges of the 21st century, particularly in developing megacities, where rapid population growth and economic expansion have significantly contributed to rising carbon dioxide (CO_2) emissions. Developing megacities account for a substantial share of global emissions, with urban centres such as Shanghai, Chennai, Jakarta, and Guangzhou exceeding the emissions of many developed cities. Despite various mitigation strategies, these megacities face difficulties in effectively managing their carbon footprints due to infrastructural inefficiencies and limited policy frameworks. Direct Air Capture (DAC) technologies have emerged as a potential remedy, yet conventional systems are often energy-intensive, requiring approximately 471 kJ/kg CO_2 for atmospheric capture. As an alternative, bio-based methods such as urban trees offer a sustainable solution for carbon capture in megacities. However, space constraints and environmental factors limit their effectiveness. For instance, high concentrations of CO_2 and pollutants can hinder tree growth. This is evident with *Ligustrum lucidum* in Mexico City, where pollution causes stomatal closure, limiting carbon capture. Alternative technologies, such as microalgae-based carbon capture systems, have gained attention in urban areas with limited green space. Microalgae-based DAC systems offer a promising alternative, achieving photosynthetic efficiencies up to 50 times greater than traditional urban trees. Microalgae can effectively capture approximately 1.83 kg of CO_2 per kg of biomass, with capture efficiencies ranging from 80% to 99%. Notably, a microalgae culture spanning 100,000 km² could capture up to $2.35*10^9$ tonnes of CO_2 annually, contributing to a significant 5.31% to 8.01% reduction in global CO_2 emissions. Case studies in urban settings such as Mexico City have demonstrated that microalgae bioreactors can effectively offset CO_2 emissions of 170,726 tons by producing 94,847 tons of biomass daily within a cultivation volume of 0.22 km³. The integration of microalgae-based DAC systems addresses the pressing issue of CO_2 emissions in densely populated developing megacities, though research studies are limited in the literature. This work explores techno-economic and environmental requirements to deploy microalgae-based DAC systems in developing megacities and assesses constraints that hinder the applications. Thus, this study contributes to sustainable urban development and enhanced climate resilience, targeting carbon neutrality by 2050.

Keywords: Carbon Neutrality; Direct Air Capture (DAC); Developing Megacities; Microalgae; Sustainability

Corresponding author email: saman.ilankoon@monash.edu

GREEN BIOPOLYMER TECHNOLOGY – HARNESSING PURPLE BACTERIA FOR SUSTAINABLE MATERIALS

Klopchevska J.*, *Rafajlovska V.

Faculty of Technology and Metallurgy, Ss. Cyril and Methodius University in Skopje, Rudjer Boskovic 16, 1000 Skopje, Republic of North Macedonia

Abstract

The global shift toward sustainability has heightened interest in biopolymers as eco-friendly alternatives to conventional plastics. Among various microbial systems, purple non-sulfur bacteria (PNSBs) have recently gained attention for their unique potential in biopolymer production, particularly polyhydroxyalkanoates (PHAs), a class of biodegradable plastics.

This review paper examines the innovative technologies that leverage the metabolic flexibility of PHAs to produce green biopolymers using low-cost, renewable substrates and environmental processes. The recent advancements in the biotechnological exploitation of PNSBs, including novel bioreactor designs, genetic engineering techniques, and metabolic optimization strategies that enhance biopolymer yield and quality are pointed out. A critical evaluation of the challenges and opportunities associated with scaling up these technologies is presented, alongside an assessment of their environmental and economic impact. The paper also explores the integration of purple bacteria-based biopolymer production into circular economy models, emphasizing the potential to utilize industrial waste streams and reduce the carbon footprint of plastic manufacturing. Comparisons with other microbial systems are made to highlight the distinctive advantages of purple bacteria, such as their ability to thrive under anaerobic, phototrophic conditions and their utilization of diverse carbon sources.

By consolidating key findings from recent studies, this review comprehensively presents and identifies state-of-the-art innovations in green biopolymers production, future research directions, and the potential pathways for their industrial adoption.

Keywords: Purple bacteria, Microbial Engineering, Polyhydroxyalkanoates (PHA), Sustainable Circular Economy

Corresponding author email: jana@tmf.ukim.edu.mk

PERSPECTIVES OF THE SOLID-STATE FERMENTATION IN DEVELOPMENT OF LIGNOCELLULOSIC BIOREFINERIES

Tišma M.

Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, F. Kuhača 18, HR-31 000 Osijek, Croatia

Abstract

Lignocellulosic biorefineries are factories for the production of various bio-based products (biofuels, biochemicals, biomaterials, food and feed) using lignocellulosic non-edible biomass (waste from agriculture, food industry, wood industry and forestry, municipal solid waste, etc.) as feedstock. The commercialization of lignocellulosic biorefineries is still rare worldwide due to challenges related to the raw material supply chain and the sustainability of pre-treatment and conversion methods.

Solid state fermentation (SSF) is one of the environmentally friendly methods that can be used in lignocellulosic biorefineries. SSF is a fermentation process carried out in the absence of free water on non-soluble materials, such as e.g. lignocellulosic biomass, that can serve as a physical carrier and nutrient source for microorganisms.

In recent years, research worldwide has focused on the production of high-value products, protein enriched fermented food and feed as well as biomaterials and biofertilizers, using solid-state fermentation.

In this work examples of the use of food industry by-products as substrates during SSF for the production of a variety of bio-based products based on lignocellulosic biorefinery concepts will be given.

Keywords: solid-state fermentation, lignocellulosic biorefineries, lignocellulosic biomass, bio-based products

Corresponding author email: marina.tisma@ptfos.hr

LIFE CYCLE ASSESSMENT AND THERMODYNAMIC MODELING OF BIOFUEL PRODUCTION FROM BIOMASS VIA FISCHER-TROPSCH SYNTHESIS

Gholizadeh T.*, *Ghiasirad H.*, *Skorek-Osikowska A.

Silesian University of Technology, Faculty of Energy and Environmental Engineering, Poland

Abstract

The European Commission's Energy Union agenda seeks a significant overhaul of the continent's energy infrastructure, emphasizing more intelligent, adaptable, and cohesive methods for energy distribution [1]. This plan requires substantial (substantial alterations) in the current energy and fuels sector, with a pronounced focus on renewable energy sources (RES), (smart and diversified energy systems), and the principles of the circular economy [2]. The hydrogen economy has gained prominence in global and national energy policies [3,4], leading to the proposal of a polygeneration system in this paper.

The proposed system begins with biomass entering the anaerobic digestion system, where it is converted into digestate and biogas. The generated biogas undergoes mechanical and thermochemical processing, which includes a reformer, a water-gas shift reactor (WGSR), and a pressure swing adsorption (PSA) system. During these stages, methane and carbon dioxide are separated, leaving a stream of hydrogen and carbon monoxide with a specified molar ratio. This H_2 and CO mixture is then fed into the Fischer-Tropsch (FT) reactor.

Within the FT reactor, a range of hydrocarbons, including paraffins and olefins, are produced. These products then proceed to distillation columns, where they are separated into various liquid fuels—specifically gasoline (C_5–C_9), jet fuel (C_{10}–C_{13}), and diesel (C_{14}–C_{20}). Additionally, a furnace-combustor unit burns the tail gases, generating heat at approximately 1000°C. This heat is utilized to maintain necessary temperatures in units such as the reformer, anaerobic digester, and heat exchangers throughout the process. Furthermore, the mechanical energy required for this proposed system is supplied by renewable energy sources, enhancing the sustainability of the entire process.

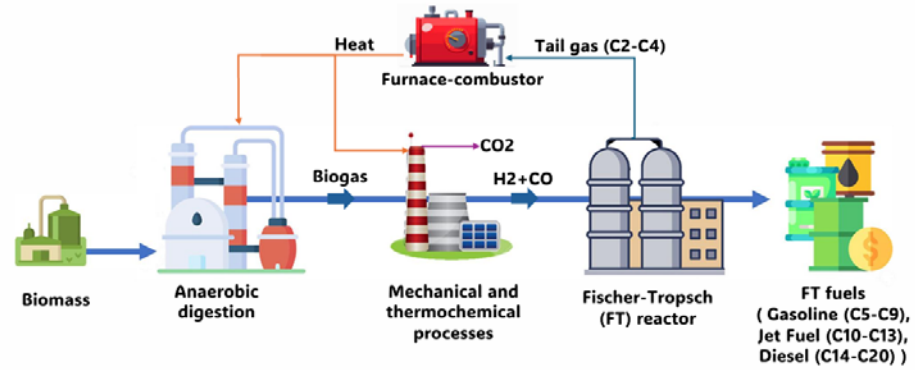

Figure 1 Simplified Process Flow Diagram for Biofuel Production from Biomass Using Anaerobic Digestion and Fischer-Tropsch Synthesis

The objective of this study is to evaluate the efficiency of the proposed biofuel production pathway and to identify optimization opportunities by analyzing the strengths and potential limitations within the system. A comprehensive Life Cycle Assessment (LCA) will be conducted to assess the environmental impacts associated with each stage of the process, from biomass digestion to fuel production. Using a streamlined model that incorporates the complete value chain, essential process interconnections, and LCA metrics, this analysis demonstrates that integrating anaerobic digestion, thermochemical conversions, and Fischer-Tropsch synthesis enables the sustainable and efficient production of high-value liquid fuels from biogas. Additionally, the system's design leverages thermal integration, heat recovery, and renewable energy inputs to minimize greenhouse gas emissions. This approach not only supports carbon-neutral fuel production but also contributes to circular waste management, providing insights into environmental performance and offering potential as a renewable energy storage solution. Consequently, the system enhances grid stability while mitigating CO_2 and methane emissions throughout its lifecycle.

Keywords: Life Cycle Assessment (LCA), Fischer-Tropsch Synthesis, Anaerobic Digestion

Corresponding author email:

Towhid Gholizadeh, (Towhid.gholizadeh@gmail.com, Towhid.gholizadehbaris@posl.pl)

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REFERENCES

[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

[2] Lümmen N., Røstbø E.V. Biowaste to hydrogen or FT fuels by gasification – A Gibbs energy minimisation study for finding carbon capture potential and fossil carbon displacement on the road. Energy 2020, 211, 118996.

[3] Gholizadeh, T., Ghiasirad, H., & Skorek-Osikowska, A. (2024). Life cycle and techno-economic analyses of biofuels production via anaerobic digestion and amine scrubbing CO2 capture. *Energy Conversion and Management*, *321*, 119066.

[4] Hydrogen Roadmap Europe. A Sustainable Pathway for The European Energy transition. Fuel Cells and Hydrogen 2 Joint Undertaking 2019, fh.europa.eu.

2. Green strategy embedded in biotechnology: biomass, bioenergy, and biobased products

Flash oral presentations

IMPLEMENTATION OF DEEP LEARNING MODELS IN SMOKE POINT PREDICTION FOR CLEANER AND EFFICIENT FUELS

Abakar Ruaa.[1], Abdul Jameel Abul Gani[1,2]

[1]King Fahd University of Petroleum and Minerals, Academic belt road, 3126, Dhahran, KSA
[2] Interdisciplinary research center for refining and advanced chemicals Academic belt road, 3126, Dhahran, KSA

Abstract

Combustion of conventional hydrocarbon-based fuels significantly impacts the environment due to the emission of particulate matter, particularly soot. Soot contributes to air pollution, global warming, and deterioration of human health. To mitigate these effects, this study investigates the addition of oxygenated functional groups—specifically alcohols, ethers, and ketones—to toluene primary reference fuel (TPRF) blends. In this study Ethanol (EtOH), n-Pentanol (n-PeOH), Isopropanol (i-PrOH), Isobutanol (i-BuOH) 2-Methyl-2-Butanol (2MB2OL), Methyl tert-Butyl Ether (MTBE), Ethyl tert-Butyl Ether (ETBE), Diethyl Ether (DEE), Dibutyl Ether (DBE), Cyclohexanone (CHN) and Cyclopentanone (CPN) where investigated

Experimental results reveal that blending oxygenated additives increases the smoke point (SP) of fuels, significantly ethers such as DBE. These reduce soot formation and support the transition to cleaner, more sustainable fuels. By raising SP values, oxygenates enhance fuel efficiency, lower environmental impact, and promote cleaner combustion.

Additionally, dataset of 82 used for a deep neural network (DNN) model to predict the SP of diverse oxygenated fuel mixtures. The model achieved a high accuracy with an R-squared value of 0.97 on the test set, Root Mean Squared Error (RMSE) of 0.23 and Mean Absolute Error (MAE) of 0.18. demonstrating its reliability in predicting SP and assessing soot reduction potential. This predictive capability accelerates the evaluation of potential fuel blends, improving cleaner fuel technologies and decreasing dependency on costly experimental techniques.

Keywords: TPRF; Smoke Point; Oxygenates; neural network

Corresponding author email: a.abduljameel@kfupm.edu.sa

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SDAIA Joint Research Center for Artificial Intelligence, King Fahd University of Petroleum and Minerals

COMPLETE GENOME SEQUENCE OF VIBRIO GAZOGENES PB1: AN ESTUARINE BACTERIUM CAPABLE OF PRODUICING PRODIGIOSIN FROM STARCH OR CELLULOSE

Baby B.[1,2], Vijay D.[1], Philip P.S.[3], Alnuaimi A.A.[1], Almansoori H.M.[1], Areidat S.O.[1], Khan G.[3,4], Vijayan R.[2,4,5] and Akhtar M.K. [1]

[1]Department of Chemistry, College of Science, United Arab Emirates University, Al Ain, UAE
[2]Department of Biology, College of Science, United Arab Emirates, University, Al Ain, UAE
[3]Department of Medical Microbiology and Immunology, College of Medicine and Health Sciences, United Arab Emirates University, Al Ain, UAE
[4]Zayed Center for Health Sciences, United Arab Emirates University, Al Ain, United Arab Emirates
[5]The Big Data Analytics Center, United Arab Emirates University, Al Ain, United Arab Emirates

Abstract

Vibrio is a genus of gram-negative, rod-shaped, motile bacteria commonly found in saltwater. One species in particular, *Vibrio gazogenes* PB1, sourced from an estuarine environment, is known to produce the secondary metabolite, prodigiosin. This high-value compound has potential uses as an antibiotic, a fungicide, and an anti-cancer agent. To further explore its metabolic and genetic features for biotechnological purposes, the complete genome sequence of *V. gazogenes* PB1 was determined by Illumina and Pacbio sequencing. Two chromosomes were assembled with a mean coverage of 293x. Chromosome 1 is 3.5 Mbp in size with 45.3% GC content and chromosome 2 is 1.2 Mbp in size with 45.1% GC content. The entire genome harbours 4178 genes, of which 3988 are protein-coding and 114 are RNA-coding. Six genes associated with the degradation of cellulose and starch were also identified within the genome. Four of them were strongly up-regulated, as confirmed by RT-qPCR, thus providing strong evidence for their involvement in starch and cellulose degradation. Quite importantly, we demonstrate for the first time that starch and cellulose is associated with the synthesis of prodigiosin in a native prodigiosin-producing bacterium. The prodigiosin titres obtained in the presence of cellulose were on par with glucose as the carbon source which lends further support in the use of *V. gazogenes* PB1 as a biotechnological host for prodigiosin production.

Keywords: high-value compound, polysaccharide, marine, virulence, degradation
Corresponding author email: mk.akhtar@uaeu.ac.ae
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2. Green strategy embedded in biotechnology: biomass, bioenergy, and biobased products

Posters

EVALUATION OF GROWTH AND PIGMENTATION OF *TERANA CAERULEA* FUNGUS IN DIFFERENT CULTIVATION CONDITIONS

Aquino Y.[1,2], Fernandes I.[1,3], Martins A.[1], Lage M.[2], Calhelha R.C.[1], Heleno S.A.[1]

[1]CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[2]Nutrition and Bromatology Group, Universidad de Vigo, Depart of Analytical Chemistry and Food Science, Faculty of Science, E-32004 Ourense, Spain
[3]Tree Flowers Solutions, Lda. Edifício Brigantia Ecopark, 5300-358, Bragança, Portugal.

Abstract

The fungus *Terana caerulea* (Lam.) Kuntze (Phanerochaetaceae) has a characteristic blue coloration, resulting from a mixture of polymers related to telephoric acid. This property demonstrates its ability to produce cobalt blue pigments, arousing the interest of the natural dye industry. *T. caerulea* is found mainly in warm and humid forests, growing on the underside of fallen tree trunks and branches.

The present study aimed to isolate the fungus *in vitro* and evaluate the ideal growth conditions of *T. caerulea* for subsequent pigment production. For this purpose, a growth rate was evaluated in two solid culture media: modified Melin & Norkrans (MMN) and Potato Dextrose Agar (PDA). After initial growth, ultraviolet (UV) light exposure tests were performed to evaluate its effects on pigment production. In addition, pigmentation was verified under different light filters: yellow, red, blue, green and without filter.

The results showed that *T. caerulea* grew in both culture media, with greater pigmentation intensity and faster growth in the MMN medium. In the pigmentation tests, it was observed that the fungi grown without light filters obtained a more intense coloration, followed by those exposed to blue, green, red and, lastly, yellow filters. Thus, the use of light filters was not effective in stimulating pigment production.

New approaches are being explored to improve the cultivation, establishment and stimulation of pigment formation by *T. caerulea*.

Keywords: Natural pigments, Terana caerulea, Pigments, Dye production, Cobalt blue.

Corresponding author email: sheleno@ipb.pt

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IMPROVE THE SECRETORY EXPRESSION OF KERATINASE IN *BACILLUS LICHENIFORMIS*

***Ishaq A.R.*[1], *Shouwen C*[1].**

[1] *State Key Laboratory of Biocatalysis and Enzyme Engineering, Environmental Microbial Technology Center of Hubei Province, College of Life Sciences, Hubei University, Wuhan 430062, China*

Abstract

Background

Since the 21st century, the livestock breeding industry has developed rapidly around the world, and with it has come a large amount of animal hair waste, but it has yet to be fully utilized because it is difficult to degrade by traditional methods. The main objective of this study, to boost the expression, secretion, and activity of ideal keratinase in *Bacillus licheniformis*.

Result

Initially, the keratinase gene (*sapB*) from *Bacillus pumilus* CBS was expressed in *B. licheniformis* to achieve optimal feather hydrolysis, with soluble keratin identified as the most appropriate substrate for assessing keratinase activity. Following the optimization of expression factors and signal peptides, the strain 0A1/P_{PykzA}-UTR $_{RBS6}$-SP_{sacC}-*sapB* exhibited the highest extracellular keratinase activity, which was 128.48% higher than that of the control strain. In terms of host modification, the combined effect of deleting and overexpressing chaperones (BL10Δ*hrcA*::$P_{p43UTR12}$-*dnaJ*::$P_{p43UTR12}$-*prsA*) led to a 94.99% increase in keratinase activity. Moreover, the keratinase activity reached 28159.12 U/mL, achieving 46.98% enhancement under the optimized shake-flask fermentation conditions. Ultimately, 150 g/L concentration of feather waste was considered an ideal for biotransformation, with a degradation ratio of 93.3% achieved after an 8-hour of incubation period. The highly active keratinase (SapB) also demonstrated excellent washing performance, suggesting its potential application in the laundry industry.

Conclusion

By choosing optimal expression elements, host strain modification, and fine-tuning the fermentation process, we successfully engineered a keratinase with high keratinolytic activity, which is a robust approach to obtain extracellular keratinase suitable for a broad range of applications.

Keywords: *Bacillus licehniformis*, *Keratinase, Host modification, Discarded feathers, Washing analysis, Fermentation optimization*

Corresponding author email: 20212310701001@stu.hubu.edu.cn

GREEN BIOPRODUCTION OF VANILLIN FROM FERULIC ACID: A SUSTAINABLE APPROACH FOR AROMA SYNTHESIS AND WHOLE-GENOME SEQUENCING OF ENZYMES INVOLVED IN THE CONVERSION

***Kochupurackal J.*[1], *Mohan H.*[1]**

[1]*School of Biosciences, Mahatma Gandhi University, P.D. Hills, Kottayam, Kerala, India.*

Abstract

Vanillin (4-hydroxy-3-methoxybenzaldehyde), a phenolic aldehyde, is the primary compound responsible for the characteristic flavor and aroma of vanilla and is the second most valuable spice after saffron. As demand for natural vanillin increases, eco-friendly biotechnological methods for its production have garnered significant attention. This study explores the biotransformation of ferulic acid, an abundantly available phenolic compound, to vanillin using a bacterial strain *Burkholderia sp* CP2, isolated from coir pith (CP) soil. Enrichment culture techniques were employed to isolate CP2, and the strain was initially screened for vanillin production using the Thiobarbituric Acid (TBA) assay, which showed a yield of 0.090 µg/mL after 72 hours. Further analysis and confirmation of vanillin production were conducted using High-Performance Liquid Chromatography (HPLC) and Ultra-Performance Liquid Chromatography Quadrupole Time-of-Flight Mass Spectrometry (UPLC-Q-TOF MS/MS). Whole-genome sequencing of strain CP2 was performed to identify the key enzymes involved in the biotransformation pathway, providing insights into the molecular mechanisms underlying vanillin synthesis. This approach highlights a sustainable and efficient method for vanillin production through microbial conversion, contributing to the growing field of green chemistry and biotechnology.

Keywords: Vanillin, Ferulic acid, HPLC, UPLC-Q-TOF MS/MS, WGS.

Corresponding author email: jayachandrank@mgu.ac.in

Acknowledgment: Mahatma Gandhi University, India.

ECO-FRIENDLY BIOREMEDIATION: CONVERTING SUCRALOSE, AN EMERGING WATER POLLUTANT, INTO NOVEL POLYSACCHARIDES FOR BIOTECHNOLOGICAL ADVANCEMENTS

Al Marar H., Al Merri K., Alzaabi F., Munawar N.

Department of Chemistry, College of Science, United Arab Emirates University (UAEU), Al-Ain, UAE.

Abstract

Sucralose, a non-digestible artificial sweetener with three chlorine atoms in its chemical structure, is widely used globally, including in UAE, as a sugar substitute by health-conscious and diabetic individuals. The sucralose market, valued at USD 852.59 Million in 2022, is anticipated to reach USD 855.5 Million by 2028. However, its non-digestible nature poses a challenge, leading to its accumulation in wastewater reservoirs and classifying it as an emerging water pollutant resistant to conventional physical and chemical degradation methods. This study explores bioremediation as a viable solution to address sucralose pollution. Although sucralose is toxic to microorganisms at concentrations above 2%, our research identified four bacterial strains capable of thriving at higher sucralose concentrations (10%). Scanning electron microscope (SEM) and FTIR analyses revealed that these strains not only converted sucralose into non-chlorinated, environmentally friendly organic molecules but also synthesized unique biopolymers with distinct textures and chemistries. Notably, these polymers differ from those produced using sucrose as a substrate by the same bacteria. Our findings not only propose a green solution for treating an environmental pollutant but also demonstrate the potential to generate innovative biomaterials for sustainable and efficient biotechnological applications. Our approach emphasizes the transformative power of harnessing bioremediation for environmental and technological advancements.

Keywords: Sucralose, Bioremediation, Non-chlorinated compounds, Biopolymers, Biotechnology

Corresponding author email: nmunawar@uaeu.ac.ae

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PRODUCTION OF GREEN METHANOL TO UNLOCK LARGE-SCALE SUSTAINABLE FUELS PRODUCTION FOR THE MARITIME INDUSTRY

***Nadeem A.*[1], Rehman A.[1], Adam K.[1], Alnuaimi M.[1], Alreyami N.[1], Alkhatib I.[2], Vega L.[2]**

[1]Khalifa University, University, PO Box 127788, Abu Dhabi, United Arab Emirates
[2] Research and Innovation Center on CO2 and Hydrogen (RICH), PO Box 127788, Abu Dhabi, United Arab Emirates

Abstract

Maritime transport, responsible for approximately 2% of global CO_2 emissions, faces increasing pressure to decarbonize, with emissions projected to rise by 50-250% by 2050 under business-as-usual scenarios. This project addresses this challenge by proposing sustainable methanol production as a maritime fuel. Hydrogen production methods including hydrogen sulfide methanol reforming (H_2SMR), and alkaline electrolysis, were selected for comparison, along with CO_2 capture via post-combustion capture (PCC). For methanol production, both the Fischer Tropsch process and CO_2 direct hydrogenation were chosen. The study explores four combinations of these methods.

Each case is evaluated for technical, economic, and environmental feasibility. After simulating the cases on Aspen HYSYS, economic analysis was conducted using a cost-estimation tool called CAPCOST, and environmental impacts were assessed with life cycle analysis in OpenLCA.

The study demonstrates that hydrogen from H_2S, a by-product of oil refining, provides a regionally viable solution for the UAE. The integration of carbon capture not only reduces emissions but also contributes to a circular economy. This aligns with the UAE's Net Zero goals and international maritime regulations, offering both environmental and economic benefits. By-products of H_2SMR such as sulfur and carbon disulfide (CS_2) further reduce costs and create new revenue streams, showcasing scalable solutions for decarbonizing the maritime sector.

Keywords: Sustainable methanol production, hydrogen sulfide methane reforming (H_2SMR), carbon capture, fischer-tropsch process, maritime fuel, decarbonization

Corresponding author email: aairanadeem@gmail.com

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HYDROTHERMAL PRETREATMENT WITH AND WITHOUT OXIDANT FOR BIOGAS PRODUCTION FROM SLUDGE, DAIRY, AND WOOD RESIDUES: A CASE STUDY UTILIZING CONVENTIONAL ACTIVATED SLUDGE

***Ponte R.*[1], Shanableh A.[2,3], Inayat A.[4], Khalil W. A.[5], Luna-delRisco M.[6], Imteaz M.[7], Rocha-Meneses L.[1]**

[1] Chair of Biosystems Engineering, Institute of Forestry and Engineering, Estonian University of Life Sciences, 56 Fr. R. Kreutzwaldi Str., 51006 Tartu, Estonia
[2] Biomass & Bioenergy Research Group, Center for Sustainable Energy and Power Systems Research, Research Institute of Sciences and Engineering, University of Sharjah, 27272 Sharjah, United Arab Emirates
[3] Department of Civil and Environmental Engineering, University of Sharjah, 27272 Sharjah, United Arab Emirates
[4]Department of Energy, School of Engineering, Robert Gordon University, Aberdeen AB10 7GJ, United Kingdom
[5]MAB Environmental Consultancy & Studies LLC, Sheikh Zayed Rd - Trade Centre - Trade Centre 1, Dubai, United Arab Emirates
[6] Universidad de Medellin, Faculty of Engineering, Carrera 87, 30 – 65, P.O. 050030, Medellín, Colombia
[7] Centre for Sustainable Infrastructure and Digital Construction, Swinburne University of Technology, Hawthorn, Australia

Abstract

In this study, we investigated the effect of the hydrothermal pretreatment method with or without oxidant on cumulative biogas production, maximum biogas production, digestion time, and kinetics rate constant of sludge, dairy, and wood samples. Sludge samples pretreated with 0% oxidant at 100°C and 150°C have a cumulative biogas production between 45-46mL, while those pretreated at 200°C and 250°C have a cumulative biogas production between 35-37mL. Sludge samples pretreated with 100% oxidant at 100°C, 150°C, 200°C, and 250°C have a biogas production between 31-40mL, which is lower than the control samples. Dairy samples pretreated with 0% oxidant at 100°C, 150°C, 200°C, and 250°C have a cumulative biogas production between 37-56 mL, which is lower than the control samples. A similar trend was reported for dairy samples pretreated with 100% oxidant. At all the reaction temperatures, the cumulative biogas production is between 30-37 mL, which is 40-46% below the control samples. Wood samples pretreated with 0% oxidant at 100°C and 150°C have a cumulative biogas production between 32-36mL, while those pretreated at 200°C and 250°C have a biogas production between 26-29 mL, which is 11% lower than the control samples. Woody samples pretreated with 100% oxidant at 100°C, 150°C, 200°C, and 250°C have a cumulative biogas production below the control samples (between 30-37 mL). Overall, these results show that hydrothermal pretreatment is not effective in dairy samples, but it is suitable for sludge and wood samples pretreated at 100°C and 150°C with 0% oxidant.

Keywords: anaerobic digestion; bioenergy; bioresource recovery; sidestreams; zero-waste.

Corresponding author email: reynald@emu.ee

MICROALGAE BIOFERTILIZERS FOR A GREENER TOMORROW: REVOLUTIONIZING SUSTAINABLE AGRICULTURE

Doris Ying Ying Tang [1], ***Pau Loke Show*** [1]

[1] *Department of Chemical Engineering, Khalifa University, 127788, Abu Dhabi, United Arab Emirates*

Abstract

Microalgae-based biofertilizers offer a promising alternative to chemical fertilizers in promoting sustainable agriculture. Despite the advantages of chemical fertilizers of low cost and fast-acting, they can pose damage to the environment, such as water contamination, increased acidity level, and biodiversity loss. Studies have shown that organic biofertilizers can enhance crop productivity and improve soil quality similarly to chemical fertilizers. Microalgae with rapid growth rate and high nutrient content are particularly promising. However, the economic viability of large-scale biofertilizer production remains a critical consideration. This study investigates the potential of microalgae-based biofertilizers to support sustainable agricultural practices. In this work, we emphasize microalgae cultivation in wastewater, followed by the production of algal biofertilizers. Specifically, the effectiveness of solid and liquid algae biofertilizer on crop growth are evaluated. Our study utilizes two local microalgae species, Tetraselmis sp. and Dunaliella sp. Various concentrations of algal biomass were added to the soil, and plant growth was monitored over three months. Control groups included soil without any fertilizer and soil with conventional chemical fertilizer. The plant growth rates, survival rates, rooting ability, number of leaves, shoot development, and total chlorophyll are compared to conventional fertilizer. The elemental analysis of the soil including total nitrogen, potassium, and phosphorus contents are assessed. Finally, the heavy metal content in soils treated with conventional and algae-based fertilizers are explored to ensure the safety and efficiency of algae as biofertilizers.

Keywords: Microalgae, Biofertilizers, Bioremediation, Soil quality, Crop productivity.

Corresponding author email:doris.ying@ku.ac.ae; PauLoke.Show@ku.ac.ae

GREEN INNOVATION IN DAIRY: OPTIMIZING CHEESE RIPENING WITH OLIVE LEAF EXTRACT IN A MODIFIED ATMOSPHERE

Zandona E.[1], Cindrić I.[1], Aladić K.[2], Šimat V.[3], Jokić S.[2], Blažić M.[1]

[1]Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia
[2] Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000, Osijek, Croatia
[3] University of Split, University Department of Marine Studies, Ruđera Boškovića 37, 21000 Split, Croatia

Abstract

Cheese ripening is a complex biochemical process and the most time-consuming stage in cheese production. Considering modern consumers' demand for minimally processed foods containing only natural ingredients, there is increasing interest in the application of plant extracts as natural preservatives to extend the shelf life of dairy products. In line with this trend, this study focuses on optimizing the ripening process of cheese enriched with olive leaf extract (OLE) in a ripening chamber with a modified atmosphere. The objective was to determine the optimal concentration of OLE and the ripening conditions (ripening duration and the N_2/CO_2 ratio) to reduce ripening time, improve microbiological quality, and enhance the antioxidant potential of the cheese. The cheese was produced by adding aqueous OLE, obtained via microwave-assisted extraction (MAE), to cheese milk, with final concentrations ranging from 0 to 5.69 mg gallic acid equivalents (GAE)/g dry weight. The ripening process was monitored over 40 days at a constant temperature of 12°C, relative humidity of 78%, and 82% N_2, with CO_2 levels varying between 1000 and 2000 ppm. During ripening, physicochemical parameters, total phenolic and flavonoid content, targeted polyphenols (e.g., oleuropein), antioxidant potential, texture, color changes, and microbiological quality were measured. The study successfully optimized the cheese ripening process in a specialized chamber by determining the ideal concentration of OLE in the cheese and adjusting the CO_2 levels in the chamber. These optimizations led to a reduction in the overall ripening duration while maintaining or enhancing the quality of the cheese. The modified atmosphere, along with the right OLE concentration, can effectively accelerate ripening while preserving or even improving the cheese's nutritional and sensory properties.

Keywords: CO_2, N_2, oleuropein, antioxidant potential, microbiological stability

Corresponding author email: mblazic@vuka.hr

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3. Sustainable practices in biorefineries and waste valorisation as a key priority

Oral presentations

SUSTAINABLE BIOREFINERY: CONVERTING WHEY INTO VALUABLE PRODUCTS USING AN ENZYMATIC MEMBRANE

***Al-Mutwalli S.A.*[1], *Taher M.N.*[1], *Dilaver M.*[2], *Korkut Uru S.*[3], *Koseoglu-Imer D.Y.*[1], *Lipnizki F.*[4]**

[1]*Istanbul Technical University, 34485, Istanbul, Turkey*
[2] *TUBITAK Marmara Research Center, 41470, Kocaeli, Turkey*
[3] *Zonguldak Bulent Ecevit University, 67100, Zonguldak, Turkey*
[4] *Lund University, 22100, Lund, Sweden*

Abstract

More than 21 million tons of cheese whey are produced annually worldwide, posing an environmental risk if not properly managed. Due to widespread lactose intolerance, cheese whey, which contains lactose, can pose health problems for many individuals. Thus, the management of the cheese whey is necessary to avoid environmental and health problems. This study presents a sustainable approach for whey valorization by integrating ultrafiltration and enzymatic hydrolysis by immobilizing β-galactosidase on a ceramic membrane. This approach offers a more efficient alternative to traditional whey processing methods by simultaneously concentrating proteins and hydrolyzing lactose leading to valuable products and waste minimization. The concentrated proteins can be further processed for various food applications, while the hydrolyzed lactose can be used for lactose-free products, biofuels, and biopolymers production.

The enzyme immobilization was performed by using gelatin, followed by glutaraldehyde and different β-galactosidase concentrations (1.25-15 g/L). The enzymatic membrane's performance was evaluated by filtering acidic whey, separating the hydrolyzed lactose in the permeate and the concentrated protein in the retentate. A higher enzyme concentration led to increased immobilization efficiency and lactose hydrolysis as more enzymes attached to the empty sites on the ceramic membrane. However, after a certain concentration, the immobilization efficiency remained unchanged. An enzyme concentration of 5 g/L yielded in the optimal immobilization efficiency of 64%. The enzymatic membrane demonstrated promising catalytic activity, achieving lactose hydrolysis of 72% and protein rejection of 83%. At the end of each experiment, the membrane was chemically cleaned with a flux recovery of around 90%. This integrated approach contributes to the development of sustainable biorefinery technologies that can help address global challenges related to resource scarcity and environmental pollution.

Keywords: Whey valorization, Enzymatic ceramic membrane, Concentrated protein, Hydrolyzed lactose

Corresponding author email: sama_ali_2012@yahoo.com

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THERMODYNAMIC, ECONOMIC AND ENVIRONMENTAL PERFORMANCE OF HYDROGEN PRODUCTION VIA GASIFICATION OF REFUSE-DERIVED FUEL AND CARBON CAPTURE

***Balaban D.*[1], *Lubura Stošić J.*[1], *Bera O.*[1] *and Kojić P.*[1]**

[1] *University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia*

Abstract

Among various Waste-to-Energy technologies, gasification is one of the most promising, due to high efficiency, feedstock flexibility and carbon capture potential. This study is focused on a multi-level assessment of hydrogen production from Integrated Gasification Combined Cycle (IGCC) process with carbon capture and Refuse-derived fuel (RDF) as a feedstock. Base of the analysis is process simulation performed in AspenPlus software, that includes entrained flow gasification with syngas coolers, air separation unit, water-gas shift reactors, Rectisol carbon capture unit, pressure-swing adsorbtion (PSA) unit for hydrogen production, and a combined cycle configuration. The analysis is performed as a case study for city of Novi Sad, Serbia, where potential RDF quantities are considered, based on waste generation data (resulting in a small scale gasification plant). Also, co-gasification with coal is considered. Hydrogen production efficiencies for different process configurations are around 42% (for RDF gasification) and 58% (for co-gasification), which translates to productivity of 48-87 kg_{H2} per ton of feedstock. Economic assessment was performed via Aspen Process Economic Analyzer, where relevant prices of raw materials (RDF price of 40 €/t is assumed), products (H_2 price of 2.5 €/kg is assumed) and utilities are specified. All investigated scenarios appear profitable, with payout periods around 12-17 years. Profitability increases significantly, if captured CO_2 is considered as a product for enhanced oil recovery purposes, reducing the payout period for 2 years on average. Levelized cost of hydrogen in that case can be as low as 0.98 €/kg. Environmental performance is assessed via LCA method with system expansion and cradle-to-grave approach. Produced hydrogen, power and thermal energy allocate hydrogen produced via natural gas reforming, Serbia electricity mix and local thermal energy production, respectively, which results in net negative performance in most of environmental categories. For every investigated scenario, negative climate change impact is obtained, with co-gasification scenarios having the biggest decarbonization effect, even reaching 6500 $kgCO_{2,eq}$ per ton of RDF and coal, mainly due to carbon capture and storage. Proposed process can be significant in future waste management and hydrogen utilization strategies.

Keywords: Gasification, hydrogen, carbon capture and storage, LCA.

Corresponding author email: dario.balaban@uns.ac.rs

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GREEN VALORIZATION OF COCOA BEAN SHELLS: REDUCING SOLVENT CONSUMPTION WITH A CO_2/2-MeTHF/WATER PRESSURIZED SYSTEM

***Bragagnolo F. S.*[1,2,3], *Strieder M. M.*[1,3], *Montero L.*[3], *Cifuentes A.*[3], *Rostagno M.A.*[1], *González-Miquel M.*[2], *Ibáñez E.*[3]**

[1]*Multidisciplinary Laboratory of Food and Health (LabMAS), School of Applied Sciences (FCA), University of Campinas (UNICAMP), Rua Pedro Zaccaria 1300, Limeira, SP 13484-350, Brazil*
[2] *Dpto. Ingeniería Química Industrial y del Medio Ambiente, ETSI Industriales, Universidad Politécnica de Madrid, C/ José Gutiérrez Abascal 2, Madrid 28006, Spain*
[3] *Laboratory of Foodomics, Institute of Food Science Research, CIAL, CSIC Nicolas Cabrera 9, 28049 Madrid, Spain*

Abstract

Cocoa bean shells (CBS), which constitute 10% to 17% of the total weight of cocoa beans (Theobroma cacao L.), are often underutilized despite being rich in bioactive compounds like phenolic compounds (catechin, epicatechin, and procyanidin B2) and methylxanthines (theobromine and caffeine). These compounds hold significant potential for the food and cosmetics industries due to their health benefits. This study aimed to develop an *in silico*-guided extraction and fractionation method for these key metabolites. The Conductor-like Screening Model for Real Solvents (COSMO-RS) was used to identify a suitable solvent that could efficiently extract both methylxanthines and phenolic compounds while forming a biphasic system with water for fractionation. Based on COSMO-RS predictions, 2-MeTHF was selected, and a gas-expanded liquid (GXL) system was employed for extraction. The process began with supercritical CO_2 ($scCO_2$) extraction to defat the CBS, yielding 185.73 ± 10.13 mg/g. GXL extraction using a CO_2/2-MeTHF/water system followed, optimizing the recovery of both methylxanthines and phenolics while reducing solvent consumption by 42.69% when comparing the use of the neat solvent. A subsequent liquid-liquid extraction separated theobromine into the aqueous phase and phenolics into the organic phase, while caffeine was distributed between both. To avoid caffeine partitioning between phases, an additional approach was adopted by performing $scCO_2$ extraction with CBS adjusted to 55% moisture, enabling the complete extraction of caffeine before the GXL process. Both $scCO_2$ and GXL extracts will be analyzed using GC-MS and LC-QToF-MS/MS. Finally, this study presents a green and efficient approach to valorizing CBS through optimized extraction and fractionation.

Keywords: Green Chemistry, Biorefinery, Process Intensification, Bioactive Compounds, Partition Coefficient.
Corresponding author email: felipesb@unicamp.br
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UTILIZING DIATOMACEOUS EARTH MATERIAL AND TREATED ALKALI-RICH MINE WASTE TO DEVELOP RED CLAY BASED POROUS CERAMIC WATER EMITTER FOR URBAN GARDENING

Cabalo Lori-ann I. [1], ***De Gracia Mavel T.*** [1], ***Taylaran Angie R.*** [1]

[1]*Department of Materials and Resources Engineering and Technology, College of Engineering, Mindanao State University-Iligan Institute of Technology, Tibanga, 9200, Iligan City, Philippines*

Abstract

In this study, Kauswagan Red Clay was combined with varying concentrations of diatomite, a pore forming agent, and treated alkali-rich mine waste to increase strength of the ceramic material in order to create a porous ceramic water emitter (CWE). Hydraulic press equipment was used to formed test bar and cylindrical samples having a depth of 15 mm and a diameter of 32 mm and were pressed at 4.3 mPa. After that, samples were fired at a constant temperature of 900 °C. The findings showed that porosity rises from 49.9% to 56.91% when diatomite content is increased from 10 to 35 weight percent. The ceramic's water absorption increases from 28.52% to 37.48% and its flow rate increases from 39.39 to 46.25 mL/hr as a result of the porosity increase. Additionally, at higher concentrations of treated alkali-rich mine waste demonstrated a corresponding increase in linear shrinkage and modulus of rupture, with values ranging from 1.51% to 3.82% and 1.62 MPa to 2.93 MPa, respectively. Based on these findings, the optimal formulation for the ceramic water emitter was identified as sample N1 with 55% clay, 35% diatomite, and 10% alkali-rich mine waste. The CWE's suitability for sub-drip irrigation was evaluated for Grand Rapid lettuce plant adaptability and compared to a commercial lettuce system. The CWE's were placed in polymerizing vinyl chloride pipes with a diameter of 32 mm and were connected to the water source. Evaluation of the CWE involved monitoring the growth of lettuce plants in terms of height and the number of leaves per week, as well as measuring soil moisture, soil pH, and sunlight intensity on a daily basis. The observation of plant growth was conducted over a span of 30 days. Findings demonstrated both System 1 (with sample N1) and System 2 (reference formulation) showed potential benefits for plant growth and adaptability, with System 1 exhibiting greater success compared to System 2.

Keywords: Ceramic water emitter, diatomite, red-clay, alkali-rich mine waste

Corresponding author email: lori-ann.cabalo@g.msuiit.edu.ph

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REMOVAL OF MYCOTOXINS USING FOOD INDUSTRY WASTE

Čanak I.[1]

[1]*Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10 000 Zagreb, Croatia*

Abstract

Mycotoxins are secondary toxic metabolites of filamentous molds with a proven negative effect on health. The most common ways of introducing mycotoxins into the body involve the consumption of contaminated food. Mycotoxins can contaminate food and agricultural products at any stage of production, processing, transport, and storage.

Existing removal methods are divided into physical, chemical, and biological, but they are often insufficiently efficient or not practical for industrial application. Biosorption as a new method of mycotoxin removal offers high selectivity and specificity, low cost, and environmental acceptability.

In this study, the removal of aflatoxin B_1 (AFB_1) and fumonisin B_1 (FB_1) was investigated using food industry waste including fish bones and scales, brewer's spent grain, egg shells as well as olive pits. Experiments were conducted in phosphate (pH7) and citrate buffer (pH3) and for FB_1 additionally in simulated conditions of poultry gastrointestinal tract. Aliquots were taken in chosen time intervals and the percentage of unbound mycotoxins was determined using LC-MS/MS and HPLC for AFB_1 and ELISA method for FB_1. Results showed excellent removal of mycotoxins from buffers in amounts over 80% for every single adsorbent. The binding of FB_1 in the simulated gastrointestinal poultry tract was somewhat lower, around 38%, additionally, more experiments must be conducted due to other components of gastric juices that can interfere with and thus reduce the number of free sites for toxin binding. The obtained results significantly contribute to research on the removal of mycotoxins and the sustainability of food industry waste. Further studies are needed to get better insight into the mechanisms of binding especially in simulated animal gastric juices and to modify the adsorbent with the aim of increasing the ability to bind mycotoxins.

Keywords: mycotoxins, biosorption, food industry waste

Corresponding author email:iva.canak@pbf.unizg.hr

A NEW PROCESS FOR THE GASIFICATION OF SOLID WASTE IN SUPERCRITICAL WATER USING SOLAR THERMAL REACTORS

Caputo G.[1], Cosenza A.[1], Scargiali F.[1], Lima S.[1]
Tumminelli G.[2], Gattuso C.[2], Rizzo R.[2], Maiorana M.[2], Tuzzolino G.[2], Abate M.[2], Roccaro L.[2]

[1]Dipartimento di Ingegneria, University of Palermo, 90128 Palermo, Italy.
[2] Qohelet Solar Italia S.p.A, Corso Umberto I, n. 211, 93100 Caltanissetta, Italy

Abstract

Production of Organic Fraction of Municipal Solid Waste (OFMSW) is rapidly increasing worldwide. Usually, it is disposed in landfills or, at most, used for anaerobic digestion or composting. Considering that food wastes consist mainly of carbohydrates, lignin, proteins, lipids, and organic acids, there is potential to valorize their organic content within a circular economy framework. In this context, sustainable waste management becomes crucial for generating revenue through the conversion of waste into energy, material recovery, valuable substances, and recycling methods. Various technologies have been devised to transform biomass and other waste into environmentally friendly energy sources, encompassing fuel, heat, electricity, and organic fertilizer. The supercritical water gasification (SCWG) process could be a viable alternative. SCWG involves the conversion of organic compounds to gaseous products in an aqueous system, under conditions above its critical point (i.e. 374 °C and 22.1 MPa). Beyond the critical point, both density and viscosity decrease, enhancing the diffusivity and reducing transport limitations. Moreover, the reaction kinetics increase, because of the high temperatures, favoring cracking of heavy organic compounds to light ones. As result of the gasification of OFMSW, a high-quality syngas is obtained. To minimize the cost-effectiveness of SCWG, in this work we propose the use of solar thermal energy supplied by Fresnell solar collectors modified and adapted for high-pressure fluids and stored in an innovative heat-storing system. In this way, the exploitation of two different renewable source, as the solar thermal energy and the solid wastes, can significantly reduce the operational costs encouraging the application of this technology at industrial scale. This new process has been called SUNGAS.

In the present study, an extensive analysis, both experimental and theoretical, of the SUNGAS process has been carried out. We have modelled the whole process from a thermic and kinetic point of view, we have developed a new pretreatment process of biomass and performed gasification tests at 400/450°C and 25 MPa. Moreover, the design of an innovative continuous solar reactor at industrial scale is underway. Results show that SUNGAS could represents a feasible method for syngas production from OFMSW and similar biomass waste.

Keywords: Supercritical Water, Gasification, Municipal Solid Waste, Fresnel collectors

Corresponding author email: giuseppe.caputo01@unipa.it

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VALORISATION OF LEMON DRIED PEEL DUST TO ENHANCE THE CIRCULARITY IN THE LEMON JUICE INDUSTRY

***Esturo A.*[1,3], *Sáez G.D.*[2], *Lizundia, E.*[4,5], *Saez de Camara E.*[6], *Infante V.*[2]**

[1]*University of the Basque Country, Plaza Ingeniero Torres Quevedo 1, 48013 Bilbao, Spain*
[2] *SA San Miguel, Ruta 301 KM 33, Famaillá (4132) Tucumán, Argentina*
[3] *International Fruit and Vegetable Juice Association, 23, Boulevard des Capucines, 75002 Paris, France*
[4] *Life Cycle Thinking Group, Department of Graphic Design and Engineering Projects, Faculty of Engineering in Bilbao, University of the Basque Country (UPV/EHU), Bilbao, 48013, Spain.*
[5] *BCMaterials, Basque Center for Materials, Applications and Nanostructures, UPV/EHU Science Park, 48940, Leioa, Spain.*
[6] *Department of Chemical and Environmental Engineering, Faculty of Engineering in Bilbao, University of the Basque Country (UPV/EHU), Bilbao, 48013, Spain.*

Abstract

The lemon juice industry generates significant quantities of by-products, in particular raw lemon peel, which is usually treated as waste or used to obtain low-value co-products. In line with the principles of circular economy, this study focuses on the valorisation of lemon dried peel dust. The key background of this work lies in the increasing need for environmentally sustainable practices in the food and beverage industries, where the circular model holds substantial potential to minimize waste, to maximize resource efficiency and to drive economic profitability. This approach not only meets the growing demand for sustainable high-quality products but also enhances industry competitiveness by aligning environmental goals with financial performance.

This research explores the potential applications of lemon dried peel dust in a wide range of innovative solutions, including food, pharmaceuticals, and cosmetics. Its rich content of bioactive compounds with functional properties for health like polyphenols, flavonoids, prebiotics and essential oils make it a valuable by-product. Key results demonstrate that lemon peel dust retains these beneficial metabolites and can be effectively processed into high-value products, which include natural ingredients with technological features, dietary fibers, and antioxidants. Furthermore, the study highlights the environmental benefits of preventing waste, along with the economic advantages of creating new revenue streams from discarded materials.

By turning lemon peel waste into valuable products, this research not only reduces environmental impact but also enhances the profitability and sustainability of lemon juice production, offering a scalable solution for the industry.

Keywords: Circular economy, lemon peel valorisation, waste management

Corresponding author email: aintzane@ifu-fruitjuice.com

ADDING VALUE TO LIGNOCELLULOSIC RESIDUES THROUGH THE PRODUCTION OF NANOCELLULOSE AND NANOLIGNIN

Dias C.[1], Pires J.R.A. [1,2], Mersmann L.[1], Souza V. G.L. [1], Coelhoso I.[3], Godinho H.[4], Martins A.[2], Fernando A.L.[1]

[1]MEtRICs, CubicB, Departamento de Química, Nova School of Science and Technology|NOVA FCT, Universidade NOVA de Lisboa, Caparica, Portugal
[2]Bio4Plas - Biopolímeros, Lda, Cantanhede, Portugal
[3]LAQV-REQUIMTE, Departamento de Química, NOVA School of Science and Technology|NOVA FCT, Universidade Nova de Lisboa, Caparica, Portugal
[4]CENIMAT | I3N, Departamento de Ciências dos Materiais, NOVA School of Science and Technology|NOVA FCT, Universidade Nova de Lisboa, Caparica, Portugal

Abstract

Current demand for bio-based nanoparticles as a substitute for synthetic nanoparticles has increased due to their physicochemical properties, biodegradability and biocompatibility, and lignocellulosic wastes can be exploited for the production of cellulose and lignin derived nanoparticles. Nanocellulose (NC) and nanolignin (NL) have applications in many different areas, ranging from automotive manufacturing, agricultural, medicine, food industry, biotech industry and extending to the energetic field. Yet, the recalcitrance of the lignocellulosic material to deconstruction, requires pre-treatments as an earlier and necessary step in the process to get NC and/or NL. Therefore, the aim of the work focuses on the recent developments about the valorization of those lignocellulosic wastes as a source of NC and NL, by discussing (i) how the characteristics of different biomasses and residues influence the NC and NL properties, (ii) treatments and extraction procedures, and (iii) its categorization in terms of eco-friendly and green principles. Results show that progress has been made in greener pretreatment methods for lignocellulosic biomass, but challenges remain. The sustainability and efficiency of these methods vary by biomass type, making a universal solution impractical. While more sustainable techniques are emerging, their industrial use is limited by high costs and technical complexities, requiring specialized equipment. Overall, scaling up these developed greener methods (e.g. Deep Eutectic Solvents, steam explosion, biological/ enzymatic methods) to an industrial level requires better energy management, cost reductions, and continued innovation. Biological and are promising but limited by slower reaction rates.

Corresponding author email: ala@fct.unl.pt

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FINANCE FOR CIRCULARITY: INNOVATIONS AND CHALLENGES

Filipovska O.[1]

[1] *Geostrategic Institute Global Skopje, St. Dimche Mirchev, 3 Skopje, North Macedonia*

Abstract

The economy is significantly exposed to a spectrum of financial and non-financial risks due to climate change with heavy potential impact on sustainability and social wellbeing. The purpose of this research is primarily to deliver insights into the intersection between sustainable finance and the circular economy as one of the critical determinants for development of sustainable business models. In line with the purpose several objectives are established:

- To analyze data and current literature regarding circular economy and sustainability.
- To explore the KPI of the circular economy from a financial perspective.
- To set out recommendations for the circular economy from stakeholders' perspective.

The study analyzes data from existing sources, collected by desk research of relevant bodies of literature. At the same time, to deliver updated findings and fulfill existing gaps relevant for the chemical industry a questionnaire is designed and shared for data collection through social networks.

The expected results of this paper will contribute to the literature on sustainable innovations in finance by providing empirical evidence on the potential benefits of digitalisation for the chemical industry. The paper will also offer insights on policy implications for enhancing the fintech's role in promoting the circular economy as one of the core aspects of SDGs. It will address the channels and instruments through which fintech instruments could affect outcomes on implementation of CE business models in the chemical industry.

Finally, the paper will summarize the results and will propose directions for professionals without background in finance.

Keywords: sustainable business models, circular economy, industrial symbiosis

Corresponding author email:olivijaf@gmail.com

MICROWAVE-ASSISTED CO-PYROLYSIS OF PLASTIC WASTE AND RESIDUAL BIOMASS BIOCHAR FOR UPCYCLING INTO VALUABLE PRODUCTS

Gull T.[1], Marone M.[1], Marasco P.[1], Fedele M.[2], Salvatori M.[2], Francavilla M.[1]

[1]STAR Facility Centre, Department of Agriculture, Food, Natural Resources, and Engineering (DAFNE), University of Foggia, Via Napoli 25, 71122 Foggia, Italy
[2]Sistemi Energetici S.p.A., Via Mario Forcella 14, 71122 Foggia, Italy

Abstract

Plastic pollution has become a pressing global issue, with most of the plastic waste worldwide going unrecycled, amounting to less than 90%. Pyrolysis can efficiently convert plastics into solid carbonaceous materials, oils, and syngas, a gas mixture of carbon monoxide CO and molecular hydrogen H_2 thus contributing to the release of a circular economy and reducing the emission of greenhouse gases (GHG). Hydrogen (H_2) has been defined as a clean energy carrier for its zero-carbon nature, and plastics has been shown to be a valuable feedstock for H_2 generation, and great efforts have been devoted to the catalyst and device development. However, conventional pyrolysis faces limitations in achieving high hydrogen (H_2) yield. By providing rapid and efficient heating, microwave-assisted pyrolysis (MAP) enables better heat and mass transport, yielding different product compositions compared to conventional pyrolysis. The aim of this research activity was to investigate the MAP as promising and challenging technology for plastic waste conversion into valuable products, including hydrogen H_2, methane CH_4, liquid oils and solid carbonaceous material. Biochar achieved by conventional pyrolysis, operating at different temperatures and residence times, of local available raw biomass (byproducts and residues from agriculture, forestry, and aquaculture activity) was tested as both microwave absorber and *"low cost"* catalyst for increasing the H_2 production. Preliminary results were presented and discussed.

Keywords: Plastic Waste, Microwave pyrolysis, Biochar, Hydrogen, Methane

Corresponding author email: matteo.francavilla@unifg.it

OPTIMIZATION OF A SUSTAINABLE SOLVENT-BASED PROCESS FOR ELASTANE SEPARATION AND RECYCLING FROM BLENDED TEXTILES

***Guastaferro M.*[1], *Mancuso A.*[2], *Vaiano V.*[2], *Aliotta L.*[1], *Gigante V.*[1], *Lazzeri A.*[1], *Tognotti L.*[1], *Nicolella C.*[1]**

[1]*Department of Civil and Industrial Engineering, University of Pisa, Largo Lazzarino 2, 56122 Pisa, Italy*
[2] *Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II 132, 84084 Salerno, Italy*

Abstract

Textile recycling often requires the separation of elastane (EL), a segmented polyurethane fiber also known as spandex or LYCRA®, to enable recyclability. Elastane, typically used in small amounts (1–5 wt%) in cotton or wool fabrics and up to 20 wt% in polyester or polyamide textiles, enhances stretch and comfort in products such as sportswear and medical textiles. Despite representing only about 1% of total fiber production, elastane poses significant challenges in recycling processes. Indeed, its elastic properties can clog filters, disrupt cutting machines, and create defects in recycled fabrics. Effective EL separation methods are critical to making many elastane-containing textiles recyclable. Unlike thermal or mechanical methods, that can damage the entire textile matrix or create processing issues like unwanted strings, selective solvents target elastane more effectively. However, using non-hazardous solvents is crucial for environmental and safety reasons. Indeed, to date, only few studies have investigated EL separation from textile wastes and the main approach used was the extraction using hazardous organic solvents, such as N, N-dimethylformamide and tetrahydrofurfuryl alcohol. However, the usage of these solvents is undesired at industrial scale and a significantly shorter process time than 4 hours would be essential for a large-scale implementation. This study aimed at optimizing a solvent-based process for selectively separating elastane from blended textiles. A non-toxic organic solvent, dimethyl sulfoxide (DMSO), was identified as the best option based on a thorough comparison of literature data and theoretical models, including Hansen Solubility Parameters. Experimental tests demonstrated that DMSO could selectively dissolve EL in just 1 hour at around 120°C, starting with cotton-based fabrics. The recovered EL retained its original properties, as confirmed by thermal analyses, ensuring no degradation during the process. Additionally, the recovered EL underwent mechanical recycling and was extruded with a brittle polymer matrix to enhance its mechanical properties. To tackle contaminants like dyes left in DMSO after processing, a photocatalytic method using Titania PC50 and ZnO was implemented. This approach successfully achieved over 98% removal and mineralization of impurities. Then, the DMSO was efficiently recovered through distillation, maintaining its original solubility efficiency towards EL for reuse. By allowing the solvent to be recycled and reused, the process became more sustainable. This optimized method presents a promising, eco-friendly solution for recycling elastane-containing textiles, paving the way for broader adoption of elastane recycling.

Keywords: Textile waste, Elastane, Recycling.

Corresponding author email: mariangela.guastaferro@unipi.it

PREPARATION OF POMEGRANATE PEELS EXTRACTS RICH IN ELLAGIC ACID WITH THE AID OF ULTRASOUND-ASSISTED ALKALINE HYDROLYSIS

***Kyriakoudi A.*[1], Kalfa E., Zymvrakaki, E., Mourtzinos, I.**

[1]*Laboratory of Food Chemistry and Biochemistry, Department of Food Science and Technology, School of Agriculture, Faculty of Agriculture, Forestry and Natural Environment, Aristotle University of Thessaloniki (AUTH), 54124, Thessaloniki, Greece; ankyria@agro.auth.gr, morfok23@gmail.com, elenzym@agro.auth.gr, mourtzinos@agro.auth.gr*

Abstract

Pomegranates (*Punica granatum* L.) are usually consumed either fresh or in the form of juices, jams, jellies, liqueurs etc. Considering that the global production of pomegranates was estimated to be ~3.5 million tonnes in 2019, pomegranate processing industry generates worldwide enormous amounts of by-products, such as pomegranate peels, which constitute a rich source of phenolic compounds. In this view, pomegranate peels could be exploited as a sustainable source of ellagic acid, a compound that possesses various biological actions such as antioxidant, anti-inflammatory, anti-atherosclerotic, antiviral, anti-obesity as well as cardio-, gastro- and neuro-protective properties. Until now, the focus has been on extracting free phenolic compounds from pomegranate peels using a variety of solvents, such as water, ethanol, methanol as well as their mixtures. However, to the best of our knowledge, extremely limited are the data regarding the recovery of free and bound phenolic compounds, including ellagic acid, from pomegranate peels. In this view, the present study aimed at the liberation of ellagic acid from its bound forms via ultrasound-assisted alkaline hydrolysis, which was optimized using response surface methodology. The effect of duration of sonication, solvent:solid ratio and NaOH concentration on total phenol content, antioxidant activity as well as punicalagin and ellagic acid content was investigated. The optimum hydrolysis conditions were found to be 32 min, 1:48 v/w and 1.5 mol/L NaOH. GC-MS analysis of the obtained pomegranate peels extract revealed the presence of various phenolic compounds (e.g. ellagic acid), organic acids (e.g. citric acid), sugars (e.g. fructose) and aminoacids (e.g. glycine). The proposed methodology could be of use for food, pharmaceutical and cosmetics applications, reinforcing local economies.

Keywords: Pomegranate peels; ellagic acid; ultrasound-assisted alkaline hydrolysis; response surface methodology, GC-MS analysis

Corresponding author email: ankyria@agro.auth.gr

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SIMULATION AND OPTIMIZATION OF BIO-OIL, BIOCHAR, AND SYNGAS OBTAINED FROM THE CO-PYROLYSIS OF DATE SEEDS AND TIRE PLASTIC WASTE

***Rocha-Meneses L.*[1], Shahbaz M.[2], Inayat A.[3], Luna-delRisco M.[4], Jamil F.[5], Shanableh A.[5,6]**

[1]*Chair of Biosystems Engineering, Institute of Forestry and Engineering, Estonian University of Life Sciences, 56 Fr. R. Kreutzwaldi Str., 51006 Tartu, Estonia*
[2]*Hamad Bin Khalifa University, College of Science and Engineering, Doha, Qatar (engrshahbaz83@gmail.com)*
[3]*University of Sharjah, 27272 Sharjah, United Arab Emirates*
[4]*Universidad de Medellín, Faculty of Engineering, Carrera 87 No. 30-65, Medellín, Colombia (mluna@udemedellin.edu.co)*
[5]*Biomass & Bioenergy Research Group, Center for Sustainable Energy and Power Systems Research, Research Institute of Sciences and Engineering, University of Sharjah, 27272 Sharjah, United Arab Emirates (fsuleri@sharjah.ac.ae)*
[6]*Department of Civil and Environmental Engineering, University of Sharjah, 27272 Sharjah, United Arab Emirates (shanableh@sharjah.ac.ae)*

Abstract

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

Keywords: Bioenergy, biomass, bioresource recovery, circular economy, zero-waste.

Corresponding author email: lisandra.meneses@emu.ee (L.R.M.)
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FROM AGRO-INDUSTRY WASTE TO A BITE-SIZED SNACK: CHESTNUT SHELLS EXTRACT AS ACTIVE INGREDIENT FOR FUNCTIONAL COOKIES

***Pinto D.*[1], Almeida A.[1], Moreira M.[1], Vieira E.[1], Brezo-Borjan T.[2], Vallverdú-Queralt A.[3,4], Sarmento B.[5], Švarc-Gajić J.[2], Delerue-Matos C.[1], Rodrigues F.[1]**

[1]*REQUIMTE/LAQV, ISEP, Polytechnic of Porto, R. Dr. António Bernardino de Almeida 431, 4249-015 Porto, Portugal*
[2]*Faculty of Technology, University of Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia*
[3]*Nutrition, Food Science and Gastronomy Department, School of Pharmacy and Food Science, University of Barcelona, Campus Diagonal, Av. de Joan XXIII, 27-31, Les Corts, 08028 Barcelona, Spain*
[4]*Consorcio CIBER, M.P. Fisiopatología de la Obesidad y la Nutrición (CIBERObn), Instituto de Salud Carlos III (ISCIII), Av. Monforte de Lemos, 3-5. Pabellón 11, 28029 Madrid, Spain*
[5]*i3S – Institute for Research and Innovation in Health, University of Porto, Rua Alfredo Allen, 208, 4200-135 Porto, Portugal*

Abstract

The demand for antioxidants from natural sources, such as agro-waste, has intensified, with industries searching for bioactive molecules in alliance with the Sustainable Development Goals. Chestnut (*Castanea sativa*) shells (CS) have been explored as a prominent source of antioxidants. This study aims to explore the *in vivo* antioxidant response of CS extract prepared by Subcritical Water Extraction and previously validated by *in vitro* assays and develop functional cookies enriched with CS extract. *In vivo* studies were accomplished in rats orally treated with CS extract (50 and 100 mg/kg body weight (bw)) to evaluate antioxidant effects, anti-hemolytic activity, blood glucose and lipids levels, and histopathological analysis. After screening the CS extract as a nutraceutical ingredient, the functional cookies were developed and characterized regarding nutritional and phenolic composition, biological activities, and sensory analysis. The results demonstrated strong *in vivo* antioxidant responses by upmodulating antioxidant enzymes' activities and downregulating lipid peroxidation. Mild hypoglycemic and hypolipidemic effects were noticed in blood samples, while the safety of CS extract was ensured by histopathological studies in rats' liver and kidneys. The functional cookies were composed of carbohydrates (53.9%), fat (32.6%), fiber (5.2%), and minerals (2.1%). Phenolic acids, flavonoids, and tannins were the main polyphenols identified. Antioxidant and antiradical properties were also noteworthy, evidencing scavenging potential against reactive oxygen and nitrogen species. The sensory evaluation (n=20) accomplished satisfactory results, with panelists endorsing the acceptability of the cookies.These findings reinforced the sustainable use of antioxidants-rich CS extract as an active nutraceutical ingredient for functional cookies, attesting its efficacy and safety.

Keywords: Castanea sativa, green extraction, waste valorisation, functional foods, sustainability.

Corresponding author email: francisca.rodrigues@graq.isep.ipp.pt

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UTILIZING ULTRASOUND-ASSISTED EXTRACTION FOR THE RECOVERY OF BIOACTIVE COMPOUNDS FROM HERBAL TEA INDUSTRY WASTE

***Simić S.*[1], *Vidović S.*[1], *Gavarić A.*[1]**

[1]*Faculty of Technology Novi Sad, University of Novi Sad, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia*

Abstract

As people's awareness grows about the importance of a healthier, low-sugar, natural diet, global demand for herbal teas is on the constant rise. In 2022, the tea industry was valued at approximately 112.2 billion dollars, with an estimated 6.70 million tons of dried plant material consumed globally. This total includes both *Camellia sinensis* L. and other plants with proven biological activity. Projections suggest that by 2027, the tea industry will reach an annual production of 8.05 million tons. This surge in herbal tea production inevitably leads to an increase in waste generation, especially in the area of filter tea production. During the manufacturing of filter tea, plant material is grounded into small particles ranging from 2.00 to 0.315 mm, referred to as "fine cuts." However, this process also produces significant quantities of smaller particles - fine powder, with particle sizes less than 0.315 mm, which are often considered waste. This fine powder, known as "herbal dust," cannot be used in the production of filter tea bags due to its particle size and is typically discarded. The amount of herbal dust generated can range from 10 to 40% of the total processed material, depending on the type of plant. Given the availability, quality, and potential of this herbal dust, there is a clear opportunity for its further utilization.

In recent years, the use of Ultrasound-Assisted Extraction (UAE) has proven to be an effective method for extracting a variety of valuable or bioactive compounds from plant materials, including carotenoids, polyphenols, polysaccharides, proteins, dietary fibers, thymols, and various oils. Accordingly, a large number of studies have reported on the effectiveness of UAE in the extraction of polyphenolic compounds from a broad array of plant sources, such as grape seeds, orange peels, olive pomace, and onion solid waste. Additionally, UAE has been successfully applied to extract bioactive compounds from different types of waste and food byproducts.

Therefore, this report reflects on the application of UAE for the extraction of herbal dust obtained from the production of green tea (*Camellia sinensis* L.), lemon balm (*Melissa officinalis* L.), and hibiscus (*Hibiscus sabdariffa* L.), three plant species widely used for filter tea production. The quality of the obtained extracts was evaluated in terms of total phenolic content (TPC) and phenolic profile. The results indicate that the obtained extracts possess comparably high concentrations of major bioactive compounds, as well as total phenolic content, as the extracts obtained from the traditional extraction techniques applied on commercially available plant materials.

Keywords: Ultrasound-assisted extraction, herbal dust, tea industry, waste

Corresponding author email: wsimic177@gmail.com

GREEN BIOREFINERY OF SMALL FRUIT POMACE

Venskutonis P.R.*, *Jūrienė L.

Department of Food Science and Technology, Kaunas University of Technology, Radvilėnų rd. 19, LT-50254, Kaunas, Lithuania

Abstract

According to the FAO, roughly one-third of the edible parts of agro-food products for human consumption is lost or wasted globally. Currently the majority of agro-food waste and by-products generated during various processing steps are used inefficiently, while they contain valuable nutritive substances, which may be converted into high added value ingredients for food and other applications. Therefore, complete biorefining concept should be wider applied for increasing the sustainability of agro-food resources towards the development of "zero waste" processing technologies. Many small fruit species (commonly called berries) are known for their excellent flavour and abundance of healthy phytochemicals possessing strong antioxidant, antimicrobial, health promoting and other beneficial properties. However, due to a rapid decay after harvesting, the major part of berry crops is processed into juices and other longer shelf-life products. Pressing of fruit juice generates large quantities of by-products, which are called pomace, press-cake or marc and are rich in various valuable compounds; however, currently they are used mainly for animal feed and composting or even discarded as a waste, mainly due to a lack of scientific, technological and economic studies required for waste valorisation. This study proposes the biorefining processes for the valorisation of the selected small fruit pomace (black and red currant, raspberry, strawberry, mulberry and sea-buckthorn) using consecutive extraction with green solvents, namely supercritical CO_2 and ethanol. At optimal conditions, the yields of lipophilic CO_2-extracts, depending on berry species, were from 4.71% (strawberry) to 17.2% (raspberry seeds). The extracts consisted mainly of mono (oleic) and polyunsaturated (linoleic and linolenic) fatty acid-rich triacylglycerols, while tocopherols and phytosterols were important health beneficial micro-constituents. The defatted by supercritical CO_2 residues were strong antioxidants with the increased content of proteins and dietary fibre. In fact, single CO_2 extraction process already provides 2 above-mentioned valuable products. Further extraction of residues with ethanol (green solvent) yielded from 4.36% (black currant) to 32.15% (strawberry) of extracts, which were rich in polyphenolic antioxidants, while the final residues were enriched in proteins (up to 34.74%) and carbohydrates (up to 84.33%) consisting mainly of dietary fibre. More detailed data on the composition and the properties of the produced ingredients was obtained by different methods. In general, the proposed zero-waste biorefinery of small fruits enables to generate 2-4 valuable products, which may find applications in the development of foods, nutraceuticals and cosmeceuticals as health beneficial functional ingredients and natural additives. These products may be further fractionated by various methods for producing more specific and higher purity substances.

Keywords: Berry pomace; Supercritical CO_2 extraction; Ethanol extraction; Functional ingredients

Corresponding author email: rimas.venskutonis@ktu.lt

3. Sustainable practices in biorefineries and waste valorisation as a key priority

Flash oral presentations

CREATING MINIMUM VIABLE PRODUCTS USING BIOWASTE TRANSFORMATION METHODS

Klopchevska J.*, *Rafajlovska V.

Faculty of Technology and Metallurgy, Ss. Cyril and Methodius University in Skopje, Rudjer Boskovic 16, 1000 Skopje, Republic of North Macedonia

Abstract

Waste generated during the processing and consumption of food is a global problem that negatively affects the environment, social status, and the economy. For sustainable development, it is essential to manage biowaste from the circular economy point of view. The application of the biorefinery concept is significant, considering that products with high added value, such as biochemicals and biofuels, can be obtained from the biowaste. Depending on the chemical composition and characteristics of the substances, biowaste can be valorized by the application of conventional and eco-friendly technologies for the extraction of biologically active substances, as well as thermochemical and biochemical conversion methods to produce biofuels and energy. The obtained bioproducts are used in the food and pharmaceutical industry, cosmetics, synthesis processes, and the treatment of wastewater from various sectors.

This work involves the preparation and delivery of a methodological framework for research on how biowaste coming from 30 pre-selected SMEs and companies can be transformed into new Minimum Viable Products (MVP). The MVPs were developed as prototypes using the equipment at the Biohacking Lab in Skopje, with significant cross-collaboration and research with representatives of each of the pre-selected companies. The developed prototypes were characterized by the determination of the chemical composition, textural characteristics, color attributes, total number of bacteria and yeasts, as well as sensory characteristics.

The research and development of new valuable products is the first and most important step for the implementation of all technological stages and operations for the transformation of the biowaste to a semi-final product and a final product.

Keywords: biowaste, valorization, high value-added products, prototype

Corresponding author email: jana@tmf.ukim.edu.mk

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BIOMAAS PYROLYSIS BIO-OIL FRACTIONATION. CHARACTERIZATION AND APPLICATION AS ANTIOXIDANTS.

Fonts I., Lázaro C., Cornejo A., Sánchez J. L., Alfailal Z., Gil-Lalaguna N., Arauzo J.

Aragon Institute for Engineering Research (I3A), Thermochemical Processes Group (GPT), University of Zaragoza, 50018 Zaragoza, Spain;

Abstract

Bio-oil obtained from biomass pyrolysis has great potential for several applications after being upgraded and refined. This study established a method for separating bio-oil into different fractions based on polarity and molecular size to extract phenolic and polyphenolic compounds with antioxidant properties. The fractions were analyzed using various spectroscopic and chromatographic techniques, such as GC/MS, FTIR, UV–vis, SEC, DOSY-NMR, ^{13}C-NMR, and ^{31}P-NMR. The antioxidant properties of these fractions were tested by examining their ability to improve the oxidative stability of biodiesel.

Saccharide derived products remained in water-soluble/dichloromethane insoluble fractions. Pyrolysis lignin remained in the water-insoluble/dichloromethane insoluble fractions that showed good antioxidant potential despite its low solubility in biodiesel. Dichloromethane efficiently extracted phenolic compounds from the raw bio-oil, which were efficiently fractionated by semi-preparative Size Exclusion Chromatography. The subfractions with higher masses did not show good antioxidant abilities, which was related to the low hydroxy group content. Fractions with lower molecular weight (in the order of monomers and dimers) outperformed the greatest solubility and antioxidant potential of the crude bio-oil for biodiesel.

Keywords: Pyrolysis, Bio-oil, Fractionation, Antioxidants

Corresponding author email: jarauzo@unizar.es

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EXPLORING THE INTEGRATION OF GREEN TECHNOLOGIES IN URBAN PLANNING FOR SUSTAINABLE DEVELOPMENT IN SUDAN: BARRIERS, OPPORTUNITIES AND POLICY IMPLICATIONS

Elamin I. [1]***, Mohamed M.*** [2]

[1]*Department of Innovation and Knowledge Management, Near East University, Nicosia, North Cyprus*
[2]*Department of Education, Near East University, Nicosia, North Cyprus*

Abstract

Integration of green technologies into the urban infrastructure of Sudan faces unique opportunities and challenges to achieve sustainable growth and development. This research explored the importance and the possibilities for building sustainable cities in Sudan by incorporating green technologies, addressing gaps in current literature on sustainable urban development in arid regions and limited studies on the unique environmental challenges for Sudan. The study used a qualitative research approach, with a focus on secondary content analysis on current policy, international reports and academic studies to enhance engagement in understanding urban sustainability in Sudan. Moreover, to provide practical lessons to adapt to Sudanese context, other related case studies in the similar arid region were analyzed like Masdar City (UAE), Ouarzazate (Morocco), and Kigali (Rwanda). The findings showed potential in utilizing renewable energy especially solar power, however, the barriers according economic, cultural and political level could play a significant role in inhibiting sustainable projects. Furthermore, thorough analysis indicated lack of government policy framework implementation and eco-friendly technologies while being committed to international environmental agreements i.e. Paris Agreement. A substantial barriers to steady sustainable projects also found in both economic and political sides, such as insufficient funding and costly imports of green technologies. To make successful urban sustainable projects in Sudan, a new adoption of technology and cultural factors are highly Influencing. The results of study have important implications for policymakers, urban planners, and international organizations seeking to improve and aid long-term development in Sudan. Efforts to enhance implementation of sustainable practices and adapt to local environmental conditions are required to ensure future sustainability initiatives and practices.

Keywords: Sustainable cities, Green technologies, Urban development, Sudan, Qualitative content analysis

THIN-LAYER INTERMITTENT NEAR INFRARED DRYING OF OLIVE POMACE: A GREEN APPROACH TO IMPROVE RECOVERY OF BIOACTIVES

Pyrka I., Nenadis N.

Laboratory of Food Chemistry and Technology, School of Chemistry, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

Abstract

Olive pomace is one of the main by-products of the olive oil industry, consisting of pit, skin, pulp and water content that varies depending on the oil extraction process (two-phase or three-phase mills). Due to high phenol, lipid and organic acid concentrations, olive pomace poses environmental challenges, necessitating recycling and valorization efforts. Common practices for olive pomace processing include residual oil extraction, energy recovery, and soil amendment. Given its rich composition in phenolics and triterpenic acids, i.e. hydroxytyrosol, tyrosol, maslinic and oleanolic acids -compounds known for their antioxidant, antimicrobial, antiviral and anticancer properties- olive pomace is also a valuable resource for the Food and Feed industries. Before utilization, adequate drying of olive pomace is essential to preserve its functional properties and to prevent microbial and enzymatic alterations. This step is particularly critical for pomace derived from two-phase olive oil mills, where moisture content is usually higher than 65%. Towards this direction, intermittent infrared radiation is explored as an innovative, fast and eco-friendly drying technique, as it provides direct and uniform heating of the sample without needing preheating. The present work aims to study the drying process of a two-phase olive pomace at five different temperatures (70, 90, 100, 120 and 140 ºC) using a NIR thermobalance, regarding the recovery of bioactive compounds and mathematical modeling of the kinetics. Dried pomaces were analyzed for their total phenolic content (Folin-Ciocalteu assay), antioxidant activity (DPPH and CUPRAC assays) and main individual phenols and triterpenic acids (HPLC-DAD). Results showed that at 140 ºC, olive pomace presented the shortest drying time (~40 min) and the highest levels of total and individual phenolic content, antioxidant activity and triterpenic acids, proving that the use of high temperature for a short time preserves the concentrations of bioactive compounds. The efficiency of NIR was compared to the most used technique, the oven-drying at 140 ºC, which required much more time (~136 min) and the non-thermal and expensive freeze-drying. Findings indicated that NIR drying provided equal or better results, while concomitantly reducing the energy consumption, considering the shorter and intermittent process.

Keywords: Olive pomace, Infrared drying, Kinetics modeling, Antioxidants, Bioactives

Corresponding author email: niknen@chem.auth.gr

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3. Sustainable practices in biorefineries and waste valorisation as a key priority

Posters

FROM WASTE TO VALUE: CONVERTING EGGSHELLS INTO CALCIUM SALTS, EGG WHITE PROTEINS AND EGGSHELL MEMBRANES

***Budžaki S.*, Ostojčić M., Stjepanović M., Velić N., Strelec I.**

Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia

Abstract

As the world's population grows, so does the demand for various resources, leading to an increasing generation and accumulation of waste of all kinds, on a daily basis. One of the fastest growing waste streams comes from the agri-food industry. However, waste from this sector shouldn't simply be discarded, as it contains valuable biological compounds that can be reused as secondary raw materials for the production of high-value products such as chemicals, fine chemicals, nutraceuticals, pharmaceuticals, enzymes and more. Current research in the field of waste management in the agri-food industry is focused on the complete utilization of waste and oriented towards a zero-waste model. This path represents a major challenge for sustainable waste management as the basis of the circular bioeconomy. In this context, current research is exploring the potential for the full utilization of eggshell waste (ESW) for the simultaneous production of calcium salts as food-grade additives, adherent proteins from egg whites, and eggshell membranes as potential carriers for the enzyme immobilization. The processing of ESW included water rinsing followed by treatment with three different acid solutions (5% HCl, 10% CH_3COOH and 15% *o*-H_3PO_4). Protein solution obtained after water washing of ESW contained 16.1 mg of proteins per 1 g of ESW with 4,585 U of lysozyme activity. Treatment of 100 g of ESW with acids resulted in high yields of calcium salts: calcium chloride anhydride (102.42 ± 3.31 g), calcium chloride dihydrate (108.74 ± 3.62 g), calcium acetate monohydrate (111.41 ± 2.13 g) and calcium hydrogen phosphate (77.06 ± 6.21 g). Obtained salts met all prescribed criteria for food-grade additive, except calcium acetate monohydrate, which not met the criteria for water insoluble and formic acid and oxidizable impurities content. In addition to the calcium salts, eggshell membranes were also obtained in an amount of about 2.8 g per 100 g of ESW. Produced membranes showed a promising potential as enzyme immobilization carrier.

Keywords: eggshell waste utilization, calcium salts, eggshell membranes, immobilization carrier

Corresponding author email: sandra.budzaki@ptfos.hr

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BIOREFINING SEED PRESS CAKE INTO VALUE ADDED FUNCTIONAL FOOD INGREDIENTS BY CONSECUTIVE SUPERCRITICAL CO_2 AND PRESSURIZED LIQUID EXTRACTIONS

***Mouandhe I. H.*[1], *Laura T.*[2], *Petras R.V.*[1]**

[1] *Kaunas University of Technology, Department of Food Science and Technology, Radvilėnų pl. 19, Kaunas LT-50254, Lithuania*

Abstract

After extraction of oil from hempseeds, residual press cake (HSPC) is discarded or used as fertilizers. Besides the nutritional aspect, this by-product may be considered as a source of health beneficial bioactive compounds. Finding novel sources of food ingredients, reducing environmental impact, and aligning with the UN sustainable development goals are the principal driving forces that prompted us to explore this under-utilized material. Consequently, this study aimed at biorefining hempseeds press cake into higher added-value food ingredients. Proximate composition analysis of HPC was followed by supercritical CO_2 extraction ($SCCO_2$) to isolate lipophilic compounds. The defatted material was subjected to pressurized liquid extraction (PLE) using ethanol and water. Antioxidant capacity of the products obtained was evaluated by the in vitro assays, fatty acid and phytochemical composition of the fractions was analyzed by gas chromatography and ultra-high-performance liquid chromatography with flame ionization and mass spectrometric detectors. The yield of $SCCO_2$ extract was slightly enhanced as the content of carbohydrates in the residue increased, from 50.13% to 52.74%. Linoleic, α-linolenic , and oleic acids were the main fatty acids found in the extracts. On the other hand, PLE using water as solvent resulted in the highest yield of extract with 19.07 % for HHR. Moreover, only traces of cannabinoids were found in the press cake with 0.03% 0.02%, 0.02%, and 0.02% for CBDV, CBDA, CBD, and CBC, respectively. The highest values of antioxidant capacity were displayed by ethanolic extracts including 49.53 mg GAE/g, 30.13 TEAC mg Trolox/g, and 184.28 mg trolox/ g for total phenolic content, DPPH and CUPRAC, respectively. In this investigation, $SCCO_2$ and PLE resulted in three main fractions with superior functional properties. The defatted materials showed enhanced nutritional content whereas the lipophilic extracts had high fatty acids profile. In addition, PLE extracts exhibited important antioxidant properties for HSPC. In conclusion, HSPC has emerged as a promising source of higher added-value food ingredients, however, more studies are required to assess their microbiological safety and their bioavailability, particularly in cereal based products.

Keywords: Press cake, valorization, green extraction, By-products, hempseed

Corresponding author email: mouandhe.imamou@ktu.edu

LEVERAGING TREATED MINING WASTE FROM LIBONA, BUKIDNON AND PHILIPPINE RED CLAY TO DEVELOP SELF-CLEANING CERAMIC GLAZE FOR STONEWARE ROOF TILES

***Lori-ann I. Cabalo*[1], *Hamdy L. Omping*[1], *Aeron M. Macasinag*[1], *Kaye Junelle M. Pantaleon*[1] *and Magnolia Shirley B. Sumalpong*[1]**

[1]*Department of Materials and Resources Engineering and Technology, College of Engineering, Mindanao State University-Iligan Institute of Technology, Tibanga, 9200, Iligan City, Philippines*

Abstract

Self-cleaning materials have garnered significant attention due to their unique properties and potential applications in energy and environmental sectors. However, traditional ceramic roof tiles and substrates often lack these self-cleaning properties, allowing dirt and microorganisms to thrive on their surfaces. This can not only compromise aesthetic appeal but also pose health risks. This study aims to mitigate the growth of microorganisms on ceramic roofing tiles by applying a ceramic glaze formulated with treated mining waste. Specifically, we explored the use of Gango, Libona treated mining waste, which contains titanium dioxide, to create a self-cleaning ceramic glaze for roof tiles. The glaze formulation was developed using materials identical to those in the tile body: Gango Libona treated mining waste, Kauswagan red clay, and feldspar, with variations including and excluding an additional 2% of commercial TiO_2.Ceramic roof tiles were produced using slip casting, with the glaze applied through dip-coating and air spraying, followed by firing at 1150°C. Both uncoated and coated tiles were characterized for their physical properties. The photocatalytic performance of the coated tiles was evaluated by measuring the degradation of silver nitrate under ultraviolet light, while self-cleaning capabilities were assessed using the sessile drop method. The impact of acidic and alkaline solutions, as well as pH changes, on the coated tiles was also analyzed.Finally, both coated and uncoated tiles were installed on a model roof structure to evaluate their runoff properties. Results demonstrated that both the ceramic body and the glaze derived from treated mining waste significantly enhanced the performance of ceramic roof tiles.

Keywords: Treated mine waste, titanium dioxide, self-cleaning, ceramic roof tile, ceramic coating

Corresponding author email: lori-ann.cabalo@g.msuiit.edu.ph

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DENDRITIC SILICA WITH HIERARCHICAL POROSITY FROM RICE HUSK WASTE FOR LOW-PRESSURE REVERSIBLE H_2 STORAGE

Amanuel Gidey Gebretatios [1, 2], Fawzi Banat [2], and Chin Kui Cheng* [1, 2]

[1]Center for Catalysis and Separations (CeCaS), Khalifa University, P.O. Box 127788, Abu Dhabi, UAE
[2]Department of Chemical and Petroleum Eng., Khalifa University, P.O. Box 127788, Abu Dhabi, UAE

Abstract

This study presents a sustainable approach for low-pressure reversible H_2 storage using nickel-decorated dendritic silica with hierarchical mesoporosity (DHMS-RHA) derived from rice husk waste. The DHMS-RHA was successfully prepared using rice husk as a renewable silica precursor and decorated with various loadings of non-precious Ni metal for spillover-assisted H_2 storage. The prepared DHMS-RHA exhibited a well-defined dendritic morphology, as revealed by SEM and TEM images, and excellent textural properties, with a BET-specific surface area of 701.6 m^2/g and a total pore volume of 0.91 cm^3/g. The dendritic silica with an optimum Ni loading of 10 wt% (DHMS-RHA-Ni10) demonstrated H_2 uptake capacities of 4.17 and 0.13 wt% at 77 and 298 K, respectively, at 1 bar (Fig. 1). The isosteric heats of adsorption for the parent DHMS-RHA and DHMSRHA-Ni10 ranged from 6.2 to 8.1 kJ/mol and 9.7 to 24.8 kJ/mol, respectively, indicating a physisorption adsorption mechanism. The excellent H_2 adsorption-desorption reversibility under mild conditions and stable cycling performance over five consecutive cycles further supported this finding. Moreover, a detailed physicochemical characterization of the developed materials is performed. This study demonstrates the potential of developing dendritic silica from renewable silica precursors and decorating it with inexpensive metal nanoparticles to enhance H_2 storage at ambient and cryogenic temperatures.

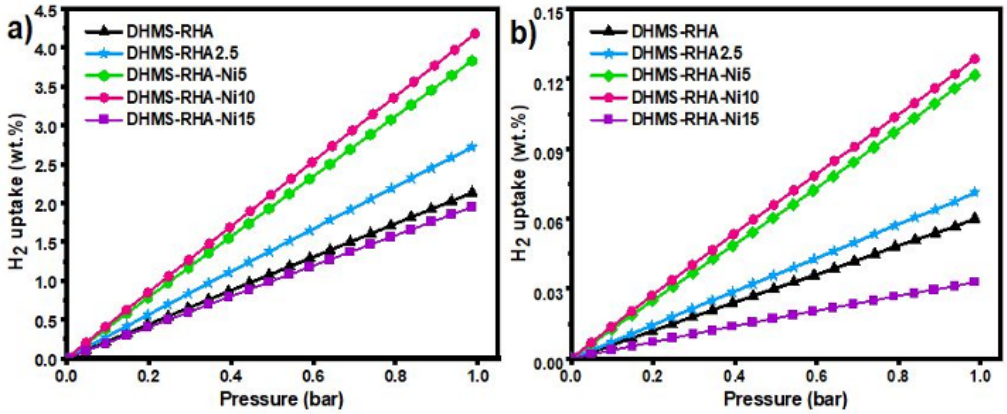

Fig. 1: H_2 adsorption isotherms at (a) 77 K and (b) 298 K.

Keywords: Sustainability, Dendritic silica, H_2 storage, Adsorption, Rice husk, Ni-decoration, H_2 spillover

Corresponding author email: cheng.kui@ku.ac.ae

THE FUTURE OF SUSTAINABLE AGRICULTURE: EMPOWERING YOUTH THROUGH DIGITALIZATION AND MULTIFUNCTIONALITY

***Cindrić I.*[1], *Blažić M.*[1], *Zandona E.*[1], *Skroza D.*[2]**

[1]*Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia*
[2]*Faculty of chemistry and technology, University of Split, R. Boskovica 35, 21000 Split, Croatia*

Abstract

Sustainable practices such as crop diversification, organic farming, and conservation tillage are essential for improving soil health, reducing chemical inputs, and conserving water. As global challenges escalate, these methods not only secure food production but also protect vital ecosystems. Digital technologies, such as precision farming, data analytics, and smart irrigation, play a crucial role in optimizing resource use, minimizing waste, and enhancing decision-making. Advanced tools like drones and soil sensors further boost farm efficiency, while digital platforms facilitate knowledge sharing and connectivity among farmers. Multifunctional agriculture extends its benefits beyond mere food production, contributing to environmental sustainability, rural development, and social well-being. Farms provide valuable ecosystem services, including biodiversity conservation and carbon sequestration, while generating additional income through agro-tourism, community-supported agriculture, and renewable energy projects. Youth education is critical for the future of agriculture. By teaching young people about sustainable farming practices and digital tools, we empower them to tackle future agricultural challenges and diversify farm operations. Through fostering innovation and sustainability in education, we prepare the next generation to lead the transformation towards a more resilient agricultural sector.

The AgriNext project plays a pivotal role in this transition by introducing innovative solutions through digitalization and multifunctionality. It focuses on integrating cutting-edge technologies into agricultural practices to enhance sustainability while maintaining productivity. The project emphasizes the importance of youth education, equipping the younger generation with the skills and knowledge necessary to adopt these technologies and multifunctional approaches. Engaging youth is essential for the long-term success of these innovations, as they are generally more receptive to digital tools and sustainable methods. Research conducted within the AgriNext project, across its four partner countries in Europe, aims to deliver practical and scalable solutions that can be adopted globally, ensuring agriculture evolves to meet modern challenges sustainably.

Keywords: education, digitalization, sustainable agriculture, multifunctionality

Corresponding author email: icindric@vuka.hr

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VALORIZATION OF COCOA BEAN HUSK AND WALNUT SHELL IN THE DEVELOPMENT OF FUNCTIONAL BIO-BASED EDIBLE FILMS

Šeremet D., Antolić M., Dominko A., Vojvodić Cebin A., Martinić A., Komes D.

University of Zagreb Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10 000 Zagreb, Croatia

Abstract

The aim of the present study was to investigate the potential of cocoa bean husk (CBH) and walnut shell (WS) as a source of bioactive ingredients in the formulation of functional bio-based edible films. The macrocomponent composition and chemical elements of CBH and WS were quantified using standard AOAC methods, while the bioactive characterization of their water extracts (100 °C, 30 min, 1 g/50 mL) was performed using spectrophotometric and chromatographic (HPLC-PDA) methods. Water extracts of CBH and WS were used to formulate edible films with alginate and plant proteins (peanut, pumpkin and rice) as carriers. The functional potential of formulated films was evaluated for their bioactive composition and physical parameters (thickness, color and texture). Dietary fiber accounted for the majority of the dry matter of both samples – 68.83 % in CBH and 93.50 % in WS, while among the macroelements potassium had the highest content – 33.64 and 2.78 mg/g, respectively. The total phenolic content in the CBH and WS extracts was 152.85 and 84.10 mg GAE/L, the antioxidant capacity measured with DPPH was 1.12 and 0.59 mmol Trolox/L and the antioxidant capacity measured with ABTS was 1.61 and 0.93 mmol Trolox/L. Among the individual bioactive compounds in the CBH extract, the methylxanthines theobromine (1.06 mg/mL) and caffeine (10.56 µg/mL) and phenolic compound epicatechin (3.22 µg/mL) were represented in the highest content. Phenolic acids including gallic acid (1.15 µg/mL) and protocatechuic acid (1.77 µg/mL) were determined in the WS extract. The same bioactive compounds were also detected in the formulated edible films. The addition of all examined plant proteins to the films led to an increase in thickness, which was most pronounced in the samples with pumpkin proteins - from 40.83 µm in the CBH control film to 92.50 µm and in the WH control film from 30.50 µm to 104.67 µm. The color parameter *L**, which indicates the brightness of the samples, was in a narrow range from 77.07 to 78.91 for CBH films and from 80.30 to 86.86 for WH films. The greatest change in the springiness of the films was determined in both samples with pumpkin proteins – from -0.03 to -2.41 mm for CBH samples and -0.05 to -0.53 for WH samples, while in the tensile strength in the samples with pumpkin proteins - from 0.02 to 0.10 MPa for CBH samples and from 0.11 to 0.18 MPa for WH samples. Considering the evaluated bioactive parameters (total phenolic content and antioxidant capacity), the formulation of the CBH extract with peanut proteins showed the highest functional potential, while in the case of the WS extract, it was the sample with pumpkin proteins.

Keywords: cocoa bean husk, edible films, polyphenols, walnut shell

Corresponding author email: drazenka.komes@pbf.unizg.hr

UNLOCKING THE POTENTIAL OF *HYPERICUM PERFORATUM* HERBAL DUST: INTEGRATION OF SUPERCRITICAL AND ULTRASOUND-ASSISTED EXTRACTION FOR MAXIMAL RECOVERY OF PHENOLIC COMPOUNDS

Krivošija S. [1], ***Jokić S.*** [2], ***Aladić K.*** [2], ***Jerković I.*** [3], ***Vlaović I.*** [1], ***Sulejmanović M.*** [1], ***Vidović S.*** [1]

[1]*Faculty of Technology, University of Novi Sad, Boulevard cara Lazara 1, 21000 Novi Sad, Serbia*
[2] *Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, Franje Kuhaca 20, 31000 Osijek, Croatia*
[3]*Faculty of Chemistry and Technology, University of Split, N. Tesle 10/V, 21000 Split, Croatia*

Abstract

Extensive production of filter tea in the last decade has increased the amount of waste generated. Namely, during industrial processing, a large amount of dust accumulates (up to 35%), which due to the size of the particles (less than 0.315 mm) cannot be packed in filter tea bags, but represents the waste of this branch of industry. The resulting residual fraction, known as herbal dust, represents a raw material that still contains a wide range of bioactive compounds that can be isolated and thereby obtain products with potentially added value. Therefore, this study is focused on the valorization of St. John's wort (*Hypericum perforatum*) herbal dust (SJWHD), which is commonly used in the treatment of mental disorders (anxiety, depression), burns, stomach ailments and various health conditions. In order to achieve the maximum valorization of SJWHD, the possibility of integrating two attractive "green" extraction methods, CO_2-assisted extraction and ultrasound-assisted extraction (UAE), was investigated. In the first step for the production of plant extracts, supercritical fluid extraction (SFE) was applied in the pressure range of 10-30 MPa, while time (4h) and temperature (40ºC) were constant. The second step was UAE of raw SJWHD, but also of exhausted material remaining after SFE, with different sonication amplitudes (20-100%), at constant time (10 min) and temperature below 50ºC. Gas chromatography combined with mass spectrometry (GC-MS) was used for the chemical characterization of non-polar and low-polar compounds isolated by SFE. Among the valuable volatile compounds, the most abundant are γ-muurolene (6.66 – 7.78%) and α-curcumene (4.98 – 6.8%). Extracts obtained by UAE were analyzed by high-pressure liquid chromatography (HPLC), where the dominant compounds were identified as rutin (946.04 –1083.7 mg/L), epicatechin (321.95 – 413.53 mg/L), and neochlorogenic acid (157.20 – 178.11 mg/L). Finally, the presented results confirm that the integration of SFE and UAE significantly improves the utilization of waste herbal dust, enabling the isolation of both polar and non-polar fractions, thus realizing the "*zero waste*" concept. Additionally, the obtained extracts contain bioactive components that can be used in various industries to produce functional products with potential health benefits.

Keywords: Hypericum perforatum; Herbal dust; Supercritical extraction; Ultrasound-assisted extraction; Waste volorization.
Corresponding author email: sladjana.krivosija@uns.ac.rs
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INNOVATIVE COUPLED GREEN EXTRACTION TECHNOLOGIES FOR SPENT COFFEE GROUNDS: FORWARD-THINKING APPROACHES TO COFFEE WASTE REUSE

Sulejmanović M. [1], ***Mourtzinos I.*** [2], ***Zymvrakaki E.*** [2], ***Krivošija S.*** [1], ***Vidović S*** [1].

[1]*Faculty of Technology Novi Sad, Boulevard cara Lazara 1, 21000 Novi Sad, Serbia*
[2] *Department of Food Science and Technology, Faculty of Agriculture, Aristotle University, 541 24 Thessaloniki, Greece*

Abstract

One of the major global problems is food waste, totaling 1.3 billion tons annually, and projected to reach two billion tons within the next decade. Addressing this issue, modern research focuses on the potential reuse of discarded by-products and food waste to develop bioactive ingredients for the food, cosmetics, and pharmaceutical industries. As coffee is one of the most consumed beverages, it should be considered in this context. According to the International Coffee Organization, world coffee bean production was almost 10 million tons in 2021/2022, with a similar amount consumed annually worldwide. By 2030, global coffee consumption is expected to reach 12 million tons, increasing waste from this industry to at least 6-8 million tons annually. This study focuses on utilizing spent coffee grounds (SCG) through well-established green, environmentally friendly coupled extraction techniques. These techniques are considered green due to their decreased energy, time, and solvent consumption compared to conventional methods. For improved bioactive compound isolation, SCG were first subjected to Supercritical fluid extraction-CO_2 (Sc-CO_2) to isolate non-polar and low-polar compounds. This was followed by Ultrasound-assisted extraction (UAE) and Subcritical water extraction (SWE) in the second stage for polar compounds isolation. The extracts were analyzed for extraction yield (EY) and total phenols content (TPC), while the chemical profile of the bioactives was characterized by HPLC. The high EY and TPC, along with the dominant compounds identified by HPLC, confirm the feasibility of using green extraction techniques with reduced environmental impact. This could direct the study toward the potential implementation of these valuable extracts in creating new functional products.

Keywords: Spent coffee grounds, Supercritical fluid extraction – CO_2, Subcritical water extraction, Ultrasound-assisted extraction, waste utilization

Corresponding author email: mirjana.sulejmanovic4@gmail.com

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SUSTAINABILITY ASSESSMENT OF A BIOREFINERY FOR MANAGING SARGASSUM OVERPOPULATION IN THE MEXICAN CARIBBEAN

Quiroz A.[1,2], Rodrigues L.[1,3], Zhukava Y.[1,2]

[1] Université de Technologie de Troyes, 12 Rue Marie Curie, 10300 Troyes, France
[2] Université de Lille, 42 Rue Paul Duez, 59000 Lille, France
[3] Università Degli Studi di Bari Aldo Moro, Piazza Umberto I 1, 70121 Bari, Italy

Abstract

Sargassum seaweed is a type of brown macroalgae that has been causing significant environmental and economic issues since 2011 due to its accumulation in massive quantities, dramatically impacting coastal ecosystems, fishing, and tourism in the Caribbean. This unprecedented influx has been linked to climate change and ocean eutrophication and is likely to continue supporting significant blooms in the future. As a result, there has been growing interest across the Caribbean region in utilising stranded and near shore floating *Sargassum fluitans* and *S. natans* as a primary resource for various purposes. Due to the high content of carbohydrates, fibres and proteins, they represent a potential feedstock for a wide range of products including high-value compounds such as pharmaceutical compounds (e.g fucoidans), and biofuels. Since the former are usually high-value compounds, they turned out to be more economically feasible as a product choice for this proposal.

This study presents a detailed sustainability assessment for a studied biorefinery [Caxiano et al, 2022] whose feedstock is *Sargassum* seaweed accumulated in the Mexican Caribbean and main product are fucoidans - compounds with bioactive properties, used in cosmetics, food, and pharmaceuticals - calcium alginate, and biofertilizer (lyophilised algal sap). The main chemical processes involved are hydrolysis and neutralisation, and only a few separation processes such as filtration and lyophilisation are required. The assessment shows that the biggest advantages of refining the brown algae are the limited use of chemicals, the low vulnerability of the inputs (*Sargassum fluitans* and *natans* could be easily replaced by other species), and the removal of tons of *Sargassum* from the sea, whilst issues are the process high energy demand and high release of wastewater. In brief, the process adds up to circularity in the local economy and all products can be used locally, reducing the environmental impact of transport. The study reveals four key challenges in producing fucoidan from sargassum seaweed in a biorefinery: arsenic contamination, high water usage, energy-intensive processes, and the seasonality of sargassum growth. If such adversities are overcome, processing *Sargassum* would reduce the environmental impacts, generate valuable byproducts, and promote circularity. However, the need for further research on technical feasibility, energy efficiency, and cost analysis are considered a must for this proposal to succeed.

Keywords: Sargassum seaweed, Fucoidans, Algal Biorefinery, Sustainability Assessment

Corresponding author email: rodriguesleog@gmail.com

INFLUENCE OF EXTRACTION METHOD AND PARTICLE SIZE ON PHENOLIC CONTENT AND BIOLOGICAL POTENTILA OF AGRI-FOOD BY-PRODUCTS

***Skroza D.*[1], *Tamara D.*[1], *Karamatić L*[1]*.*, *Brzović P.*[1], *Čagalj M.* [1], *Šimat V.*[2]

[1]*Department of Food Technology and Biotechnology, Faculty of Chemistry and Technology, University of Split, R. Boškovića 35, HR-21000 Split, Croatia*
[2] *University Department of Marine Studies, University of Split, HR-21000 Split, Croatia*

Abstract

Food processing generates large amounts of by-products and waste, especially in fruit and vegetable production, of which about 25–30% is mainly peel. Although there are many reports on the extraction of valuable bioactive components from these by-products, there are also many parameters, advantages and disadvantages of the extraction methods that should be considered, evaluated and optimized. The particle size of the sample is one of the parameters in solid–liquid extraction that significantly affects the bioactive components of natural products. Therefore, the influence of particle size of onion and pomegranate peels on phenolic composition and biological potential (antioxidant and antimicrobial activity) was investigated in this study. The by-product samples were fractionated in three sample groups characterized by different particle sizes, namely >500 um, 250-500 um and <250 um. Two extraction methods were then tested, ultrasound-assisted extraction (UAE) with 50% ethanol and accelerated solvent extraction (ASE) with water. Total phenols (TP) were determined spectrophotometrically, while antioxidant activity was evaluated using the DPPH assay. Antimicrobial activity was determined using the minimum inhibitory concentration (MIC) method against common food-borne pathogens (*Staphylococcus aureus, Enterococcus feacalis, Listeria monocytogenes, Salmonella enterica, Escherichia coli*). The results showed TP in the range of 15-156 mg GAE/ g dry samples and good antioxidant and antimicrobial activity in all extracts, especially in those prepared with UAE. The TP content of the pomegranate peel extracts was significantly higher than that of the onion peel extracts. The influence of particle size was observed between the extracts obtained using ASE. The results show that the analyzed by-products have great potential for further application in food, but additional analysis in food models should be performed to confirmed biological activity of studied extracts.

Keywords: Agri-food by-product, phenolic compounds, antioxidant and antimicrobial activity

Corresponding author email: danci@ktf-split.hr

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LIGNIN BASED RESINS FOR SUSTAINABLE COATINGS

***Smyk N. I.*[1,2], Ghotbadi S. A.[2], Sevastyanova O. B.[2]**

[1]Department of Analytical Chemistry, Taras Shevchenko National University of Kyiv, Hetmana Pavla Skoropadskoho Street, 12, 01033, Kyiv, Ukraine
[2] Department of Fiber and Polymer technology, KTH – Royal Institute of Technology, Teknikringen 56-58, SE-100 44 Stockholm, Sweden

Abstract

Lignin, a byproduct from the pulp and paper industry, has gained prominence as a sustainable alternative to petroleum-based chemicals owing to its unique properties, including an aromatic structure, high reactivity, and abundance. This makes it a promising candidate for various industrial applications, particularly in the field of coatings. Coatings are essential for protecting, enhancing the aesthetics, and improving the functionality of a wide range of materials. They are categorized based on their composition into polymer-based, solvent-based, water-based, and powder coatings, and find extensive use in industries such as automotive, aerospace, marine, and construction.

Polyurethanes, a versatile class of synthetic polymers, are widely used in applications such as foams, adhesives, elastomers, and coatings. However, there is a growing environmental concern regarding the reliance on fossil fuel-based materials in coatings. This has driven industrial efforts to explore renewable and biobased alternatives. In this context, lignin, derived from industrial black liquor at varying pH levels (pH 2 to pH 5), is being investigated as an eco-friendly component for producing novel polyurethane coatings.

The characterization of lignin samples was performed using techniques such as UV-Vis spectroscopy, FTIR, SEC, and TGA. The resulting lignin-based polyurethane coatings were thoroughly analyzed to evaluate their physical properties using methods including spectroscopy, microscopy, and thermogravimetry. Ongoing research aims to establish a relationship between the structure and properties of these innovative biobased coatings, with a particular focus on their mechanical stability.

This research represents a significant advancement in reducing the environmental impact of coatings while exploring sustainable alternatives in materials science. The development of lignin-based polyurethane coatings not only leverages a renewable resource but also aligns with the broader goals of environmental sustainability and resource efficiency in industrial applications.

Keywords: Lignin, Polyurethane, biobased coatings.

Corresponding author email:nataliiasmyk@knu.ua

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BIOREFINING OF BOTANICALS FOR HIGH ADDED VALUE FUNCTIONAL INGREDIENTS: MODERN *vs* TRADITIONAL METHODS

Venskutonis P.R.*, *Jūrienė L.*, *Baranauskienė R.

Department of Food Science and Technology, Kaunas University of Technology, Radvilėnų rd. 19,LT-50254, Kaunas, Lithuania

Valorization of plant origin raw materials and particularly their processing by-products and waste into higher value products has become an important topic in terms of increasing the sustainability and addressing environmental issues as well as a wider implementation of the 'zero waste' concept into the production. Traditional technologies usually focus on the main product, while the side-streams are recycled or discarded as a waste. For instance, distillation of essential oil-bearing plants yields on ~0.5-3.0% of the main product, while non-volatile constituents containing residues are discarded. Valorization of such residues should focus on avoiding the losses of nutrients and health beneficial bioactives compounds, protecting environment from the biowaste load and increasing economic effectiveness of the production. This study applied biorefining concept to various aromatic and medicinal plants (botanicals) by using traditional and more modern techniques for the recovery of valuable substances. For instance, the isolation of volatile lipophilic constituents was compared by the traditional hydrodistillation and optimized supercritical fluid extraction with CO_2, while the residues were further fractionated and evaluated for obtaining antioxidant and dietary fiber fractions. In case of distillation, the residual water extract was obtained by spray or freeze-drying to obtain the fraction containing non-volatile hydrophilic constituents such as polyphenolic antioxidants. Finally, hydrodistillation solids were re-extracted with medium polarity solvent to recover one more fraction. Dry supercritical fluid extraction residue was further biorefined using pressurized liquid, ultrasound and enzyme assisted extractions for obtaining several fractions with different phytochemical composition and bioactivities. For this purpose, various types of chromatographic, spectroscopic analysis and *in vitro* assays were used. The insoluble residue after all extraction and fractionation steps was composed mainly of soluble and insoluble dietary fiber components. Similar schemes, excluding distillation, were applied to the plants with negligible amounts of volatile oils. Preliminary technological upscaling, products application and economic issues have been evaluated. The products obtained could find applications in developing natural food additives (flavourings, antioxidants, antimicrobials), health beneficial ingredients for functional foods, nutraceuticals, cosmeceuticals and pharmaceuticals. Several examples on biorefining aromatic and medicinal plants will be presented, including buckwheat (*Fagopyrum esculentum* Moench.) flowers, goldenrod (*Solidago virgaurea* L.) leaves, Roman cammomile (*Chamaemelum nobile* L.) flowers, marigold (*Tagetes minuta* L.) flowers, lovage (*Levisticum officinale* Koch.) leaves.

Keywords: Botanicals; Fractionation; Essential oil; Antioxidants; Zero-waste

Corresponding author email: rimas.venskutonis@ktu.lt

ULTRASOUND-ASSISTED EXTRACTION OF AGRICULTURAL WASTE OF ONION AND GARLIC: PROCESSING PARAMETERS OPTIMIZATION AND IDENTIFICATION OF POLYPHENOLIC COMPOSITION

Vlaović I. [1], ***Krivošija S.*** [1], ***Jokić S.*** [2], ***Aladić K.*** [2], ***Nastić N.*** [2] ***and Vidović S.*** [1]

[1] *Faculty of Technology, University of Novi Sad, Boulevard cara Lazara 1, 21000 Novi Sad, Serbia*
[2] *Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, Franje Kuhaca 20, 31000 Osijek, Croatia*

Abstract

The increased generation of agricultural waste (AW), estimated at around 1.3 billion tons annually, has become a significant environmental issue, primarily due to inadequate disposal methods, negative impacts on ecosystems and limited natural resources. AW, particularly from onion and garlic processing, presents notable potential for sustainable practices and great resource recovery for bioactive compounds such as flavonoids and phenolic acids that can be utilised by various industries. Due to the insufficient recognition of the potential value of onion and garlic waste (OW, GW), a significant portion of this by-product continues to be disposed of through burning or landfilling. Traditional extraction methods for bioactive compounds from these wastes often suffer from inefficiencies, long extraction times, and the use of toxic solvents, leading to the thermal degradation of sensitive compounds. This has prompted a shift towards modern green extraction techniques, such as ultrasound-assisted extraction (UAE), which offer advantages such as shorter extraction times, extraction at lower temperatures, lower energy consumption, and preservation of the quality of extracts. Ultrasound-assisted extraction (UAE) enhances the recovery of valuable bioactive compounds and promotes sustainable practices in waste management by transforming agricultural by-products into useful resources. Considering all these factors, a comprehensive study was conducted to find the optimal method for the extraction and characterization of these valuable bioactive substances. The UAE of polyphenols from OW and GW was optimised by maximising the yield of total phenols. Specifically, the effects of extraction time (2 - 10 min) and sonication amplitude (20 - 100%) were investigated and optimised, while the temperature was defined as a constant (40ºC). Compared to conventional extraction techniques, UAE offered a higher yield of antioxidants and a shorter processing time. The dominant compounds identified were quercetin, myricetin, and protocatechuic acid in the case of OW, while in the case of GW they were epigallocatechin, epicatechin, and myricetin. The content of all compounds was the highest at the highest extraction amplitude and time (100%, 10 min), where the most dominant compound is quercetin in OW (434.76 ± 29.15 mg/L) and epigallocatechin in GW (16.65 ± 0.16 mg/L).

Keywords: Ultrasound-assisted extraction; Agricultural waste; Bioactive compounds;

Corresponding author email: vlaovicisidora@gmail.com

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4. Green solutions in development of biopolymers and advanced materials

Oral presentations

INNOVATIVE 2D NANOCOMPOSITE AEROGELS FOR ENHANCED LITHIUM RECOVERY FROM BRINE WATER

***Abdelrahman N.S.*[1], Hong S.[1], Arafat H.A.[2], Choi D.[3], and Marzooqi F.I.[1]**

[1]*Center for Membranes and Advanced Water Technology, Department of Chemical Engineering, Khalifa University, United Arab Emirates;*
[2]*Research and Innovation Center for Graphene and 2D Materials, Khalifa University, United Arab Emirates*
[3]*UAE- Korea Joint R&D Technical Center, Department of Mechanical Engineering, Khalifa University, United Arab Emirates*

Abstract

The increasing demand for lithium in electric vehicles and renewable energy sectors has raised concerns about the depletion of global lithium reserves and the environmental impacts of mining. This research addresses these issues by focusing on lithium recovery from diverse water sources, including brine, wastewater, and seawater, to promote sustainable production practices. Our primary objective is to develop a high-performance adsorbent that can be integrated into efficient lithium recovery technologies, thereby supporting a circular economy within the lithium-ion battery sector.

A significant innovation in this study is the investigation of 2D material-based nanocomposite aerogels, utilizing modified cellulose—the most abundant polymer on Earth—as the foundational structural component. These modified cellulose-based aerogels offer substantial advantages, particularly in recovery and handling, compared to conventional nanomaterials. We developed and evaluated several modified cellulose-based aerogels as lithium ion-selective adsorbents, incorporating materials such as MXene, Graphene Oxide, Deep eutectic solvents, and Ionic liquids.

The performance assessment of these aerogels in lithium ion adsorption yielded promising results, providing insights into their potential application in lithium recovery technologies. The findings of this research offer valuable strategies for reducing the environmental impact of lithium extraction while enhancing the cost-effectiveness of recovery processes, thus contributing to the long-term sustainability of the lithium-ion battery industry.

Keywords: Nanocomposite, Lithium Recovery, Adsorption, 2D Material, Renewable Resources.

Corresponding author email: nourabdelrahman13@gmail.com

AGRO- AND INDUSTRIAL WASTES AS PRECURSORS OF SUSTAINABLE CARBON-BASED ADSORBENTS IN WASTEWATER TREATMENT: PRODUCTION, FUNCTIONALIZATION, AND PHARMACEUTICAL REMOVAL EFFICIENCY

***Almeida Â.*[1], Peleja A.[1], Rocha H.[1], Sousa E. M. L.[1], Pereira G.[1], Calisto V.[1]**

[1]*Department of Chemistry and CESAM, University of Aveiro, 3810-193, Aveiro, Portugal*

Abstract

The improvement of wastewater treatments is mandatory to minimize the occurrence and the burden of contaminants of emerging concern on aquatic systems and inhabiting organisms. Carbon materials as Activated Carbon (AC) and Biochar (BC) have been widely applied as adsorbents in wastewater treatments due to their low production cost, large surface area, and surface chemical functional groups. However, they pose challenges in terms of recovery and reuse. In addition, currently available commercial options strongly depend on non-renewable fossil sources (e.g., bituminous coal), raising concerns about the sustainability of these fossil-based carbons. In opposition, agro- and industrial wastes, such as lignocellulosic residues (e.g., from crop and vegetable residues, wood, paper, cardboard) are particularly important as they are produced in tons/year. In this context, finding effective alternative precursors and overcoming the challenges associated with the recovery and reuse of the materials produced will contribute to the sustainability of advanced wastewater treatment technologies. In this work, AC and BC were made from spent brewery grains and primary sludge, collected from the brewery industry and paper mill industry, respectively. For the production, chemical activation with potassium carbonate (only in the case of AC) and microwave pyrolysis (800ºC, N_2 atmosphere) were applied, alternatively to conventional pyrolysis. After acid washing, the materials were crushed and sieved to obtain both powdered (for AC) and granular (for BC). In addition, these materials were subjected to different functionalization such as with oxidation and grafting approaches to enhance removal efficiency, incorporation of ferromagnetic metal oxide nanoparticles to create magnetic composites, promoting their easy recovery and/or physical enzyme immobilization using the oxidoreductase Laccase to enhance their reuse. The enzymatic activity of the composites with enzyme immobilization was determined. Also, the produced materials were tested for the removal efficiency of pharmaceuticals from water. Batch adsorption/degradation tests were conducted at a controlled pH, temperature, and stirring. After the contact time, samples were filtered and analyzed by HPLC. The removal efficiencies of the pharmaceutical from the materials produced were compared showing differences according to the modification performed. This research contributes significant knowledge to the advances of wastewater treatments, encouraging the use of wastes in the productive chain of carbon materials.

Keywords: wastes, adsorption, functionalization, contaminants of emerging concern, water circularity

Corresponding author email: aaalmeida@ua.pt

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GREEN REINFORCEMENT OF PLASTIC PACKAGING BY STARCH ADDITION: COUPLING COMPUTATIONAL AND EXPERIMENTAL STUDIES

***Calandra P.*[1], *Pecchia A.*[1], *Tirri B.*[1], *Mercuri F.*[1], *Lo Celso F.*[2], *Oliviero Rossi C.*[3], *Loise V.*[3], *Caputo P.*[2]**

[1]*CNR-ISMN National Council of Research – Montelibretti (RM), Italy & INSTM*
[2]*University of Palermo, Department of Physics and Chemistry, Palermo, Italy*
[3]*University of Calabria, Rende (CS), Italy & UdR INSTM della Calabria*

Abstract

Food packaging materials are typically made of polymeric blends. Poly Lactic Acid (PLA) / Poly Butylene Adipate-co-Terephthalate (PBAT) blends are generally used for this purpose, since they constitute hydrophilic and biodegradable plastic. We considered the addition of starch to PLA/PBAT blends to improve their mechanical characteristics.

Classical molecular dynamics (MD) allowed to foresee that the addition of starch can reinforce the polymeric structure via starch-polymer interactions, suggesting that starch can be a suitable material to be added to the PLA/PBAT blend to obtain more resistant packaging materials. On the other hand, experimental analysis of the mechanical properties of PLA/PBAT blends containing different amounts of starch confirmed what foreseen by MD, highlighting increases in Young modulus and glass transition as a function of added starch. Starch amount of 10 wt% turned out to be the optimum to maximize the elongation bearable under tensile stress before rupture.

The coupled theoretical/experimental approach constitutes added value of the present work, furnishing important data on the reinforcement of the packaging material performances and a molecule-based interpretation and comprehension of the observed phenomenon).

Keywords: Poly Lactic Acid, Poly Butylene Adipate-co-Terephthalate, starch, molecular dynamics.

Corresponding author email: Pietro.calandra@cnr.it

SUPERCRITICAL CO_2 STERILIZATION: A GREEN SOLUTION TO A UNIVERSAL CHALLENGE

***Carracedo-Pérez M.*[1], López-Iglesias C.[1], Ardao-Palacios I.[2], Magariños B.[3], García-González C.A.[1]**

[1]AerogelsLab, I+D Farma Group (GI-1645), Department of Pharmacology, Pharmacy and Pharmaceutical Technology, Faculty of Pharmacy, iMATUS and Health Research Institute of Santiago de Compostela (IDIS), Universidade de Santiago de Compostela, Spain
[2]BioFarma Research group, Department of Pharmacology, Pharmacy and Pharmaceutical Technology, Innopharma Drug Screening and Pharmacogenomics Platform, Centro Singular de Investigación en Medicina Molecular y Enfermedades Crónicas (CiMUS), Universidade de Santiago de Compostela, Spain
[3]Departamento de Microbiología y Parasitología, Aquatic One Health Research Center (iARCUS), Facultad de Biología, CIBUS, Universidade de Santiago de Compostela,Spain

Abstract

Rejection and patient infection during and after surgery are the main problems encountered in implant surgery. The first problem can be addressed by the development of new advanced biomaterials, such as aerogels, which are open porous materials with a high specific surface area. Especially, aerogels made of polymers and proteins are attractive in biomedicine because they are biocompatible, bioactive, biodegradable and sometimes biomimetic of the extracellular matrix. Regarding the second problem, sterility was established as a mandatory requirement and a critical quality attribute for implantable medical devices. Currently, the major drawback is that conventional sterilization techniques can cause physicochemical changes or leave cytotoxic residues in biomaterials or have limited penetration capacity in porous materials. Supercritical carbon dioxide ($scCO_2$) sterilization is an alternative technique for nanoporous and other complex materials, due to the high permeability of this type of fluids along with the microbial inactivation power of CO_2. This work outlines the development and efficacy tests of a one-step $scCO_2$ manufacturing-sterilization protocol on starch aerogel cylinders and alginate aerogel beads. In this integrated process, the efficacy of the sterilization was assessed using different standardized bioindicators and the most resistant microorganism for $scCO_2$ sterilization was identified. The textural properties of the sterile aerogels were evaluated using He-pycnometry, N_2 adsorption-desorption analysis, and SEM microscopy. The superior textural properties of aerogels were not significantly changed in the integrated process with respect to the untreated samples. Furthermore, *in vitro* cytotoxicity trials demonstrate that the materials were free of any residual toxic substances.

Sterility, Supercritical CO2, aerogels, biopolymers

Corresponding author email: maria.carracedo@rai.usc.es

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A SUSTAINABLE BIOMANUFACTURED CULTIVATED MEAT PROTOTYPE

***Deepak C.*[1]**

[1]*Biomanufacturing Technology, Bioprocessing Technology Institute (BTI), Agency for Science, Technology, and Research (A*STAR), Singapore*

Abstract

Cultivated meat has arisen as an encouraging substitute for conventional meat, thanks to its capacity for enhanced healthiness, increased ethical considerations, and sustainability. Furthermore, many research studies have identified four fundamental challenges or research pillars within this field: cell line advancement, serum-free media, edible scaffold structures, and bioprocess design. In this context, developing scaffolds devoid of animal components is essential for producing structured meat products that replicate the qualities of conventional meat, including edibility, density, nutritional value, and appropriate mechanical attributes conducive to cell growth. Creating animal-free, edible scaffolds is essential to mimic the structural complexity of conventional meat, as they offer critical physical and biological support throughout tissue development.

We have successfully developed highly macro-porous plant-based edible scaffolds through a decellularisation process, conferring a notable advantage in the biomanufacturing of cultivated meat. These scaffolds could also be generated from plant/fruit wastes as source materials; hence, valorisation is possible. Detailed physical and mechanical characterisation of the developed scaffolds was carried out to measure their mechanical properties, porosity, surface morphology, resistance to heat, etc. The aligned vascular bundles of the decellularised asparagus scaffold were selected to facilitate the attachment and alignment of murine myoblasts (C2C12) and porcine adipose-derived mesenchymal stem cells (pADMSCs). To bolster the credibility of our approach, we conducted experiments involving the cultivation of porcine adipose-derived mesenchymal stem cells (pADMSCs) on these scaffolds, guiding their transformation into muscle tissue. Simultaneously, we performed co-culture experiments with matured fat cells to make a CM prototype.PrestoBlue and Live/Dead staining of the cells in the developed scaffolds revealed enhanced cell attachment and proliferation. After subjecting the cells to serum starvation, they differentiated into myotubes, a phenomenon verified through gene expression analysis and immunofluorescence staining to detect muscle-specific markers like myosin heavy chain and Desmin. In differentiated C2C12 cells, the metabolic activity of Creatine Kinase showed a significant increase compared to proliferating cells. Quantitative PCR analysis indicated a notable rise in myosin-heavy polypeptide and myogenin expression compared to Day 0. Additionally, to develop cultured meat (CM) prototype with biological mimicry, muscle and fat cells derived from pADMSCs were co-cultured on the same scaffold. This co-culture was validated by immunofluorescence staining for muscle markers and LipidTOX staining, revealing distinct muscle fibres and lipid-containing adipocytes. Texture profile analysis of uncooked CM prototypes and pork loin showed no significant differences in textural properties. However, the pan-fried CM prototype exhibited significantly greater hardness and chewiness than the pork loin.

These findings demonstrate the potential of decellularised plant scaffolds (DPS) as a promising, edible biomaterial that supports cell attachment, proliferation, and differentiation into muscle tissue. Co-cultivation of adipocytes alongside muscle cells is a significant step towards achieving the first prototype based on decellularised scaffolds resembling real meat.

Keywords: Cultivated Meat, Biomaterials, Decellularisation, Scaffolds, Tissue Engineering, Muscle cells, Fat Cells, Valorisation, Sustainability

SURFACE ENHANCED POLYMERIC FILTERS FOR WATERBORNE VIRUS DEACTIVATION

Kareem Mujeeb O. [1,2], ***Dumee Ludovic F.*** [1,3], ***AlNashef Inas M.*** [1,2,3], ***Arafat Hassan A.*** [1,3]

[1] *Department of Chemical & Petroleum Engineering, Khalifa University (KU), Abu Dhabi, UAE.*
[2] *Center for Membrane and Advanced Water Technology (CMAT), KU, Abu Dhabi, UAE.*
[3] *Research & Innovation Center for Graphene and 2D Materials (RIC-2D), KU, Abu Dhabi, UAE.*

Abstract

Targeting submicroscopic viruses poses significant challenges in wastewater treatment, especially during a viral disease outbreak when the integrity of the treatment systems is critical for eliminating waterborne infectious pathogens. Conventional disinfection systems that enable > 99.99% (4-log) reduction of viral loads have sustainability concerns due to the utilization of substances with negative environmental footprint. However, polymeric microfiltration membranes provide an energy-efficient solution for wastewater purification either as a pretreatment or polishing step. Such membranes can capture viruses via surface adhesion, wherein pliable viruses that could easily pass through membrane pores can be captured via electrostatic interactions with the membrane surface due to their slight surface charge. In this study, nanofibers of polyvinylidene-fluoride copolymer hexafluoro propylene (PVDF-HFP) were fabricated via electrospinning, and the incorporation of 0.5 – 2wt% of an antiviral ionic liquid (IL) per polymer mass within their matrices enhanced their surface charge. The isoelectric points of these filters were all less than the pH of 3, with negative zeta potentials within the range of pH 3 to 10. These filters were chemically and thermally stable, remaining intact during water filtration without any leaching of the ILs from the polymer. This work presents a green engineering approach to incorporating an antiviral substance into a filtration system to create synergetic hybrid filters. These hybrid filters utilize the antiviral effect within surface enhanced membrane with improved capacity for targeting viruses while minimizing environmental footprint. The IL-enhanced fibers enabled up to 5-log reduction of influenza A viral load, which was higher than the pristine filters' capacity.

Keywords: virus capture, ionic liquid, membrane filtration, waterborne virus.

Corresponding author email: 100060501@ku.ac.ae

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GREEN PROCESSING OF BIOPOLYMER AEROGELS FOR BIOMEDICAL APPLICATIONS

***López-Iglesias C.*[1], *Carracedo-Pérez M.*[1], *Blanco-Vales M.*[1], *Iglesias-Mejuto A.*[1], *Illanes-Bordomás C.*[1], *García-González C.A.*[1]**

[1]AerogelsLab, Dept. of Pharmacology, Pharmacy and Pharmaceutical Technology, I+D Farma Group (GI-1645), iMATUS and IDIS, University of Santiago de Compostela, Campus Vida s/n, 15782 A Coruña, Spain

Abstract

Supercritical fluid technology, particularly supercritical CO_2 ($scCO_2$), is increasingly applied in biomedical fields due to its low toxicity, safety, and contribution to process circularity. Recently, our group has extensively explored the use of supercritical fluids to produce aerogels from various biocompatible polymers for a range of biomedical and pharmaceutical applications. By combining techniques such as 3D printing, coaxial spraying, jet cutting, and inkjet printing with $scCO_2$ drying and foaming processes, we have developed aerogels with diverse morphologies tailored for tissue engineering, wound healing, and drug delivery.

Across all applications, aerogels with high surface areas (>100 m^2/g) and porosities (>95%) were consistently produced. For colonic oral delivery, the aerogels demonstrated high cargo-loading efficiency and effectively protected the encapsulated substances from the harsh conditions of the gastrointestinal tract. In pulmonary drug delivery, combining aerogels with techniques such as inkjet printing, emulsification, or spraying resulted in formulations capable of reaching deep lung regions. $scCO_2$ also facilitated the impregnation of bioactive compounds.

In wound healing, aerogels produced via prilling or anti-solvent methods successfully delivered bioactive compounds, which significantly enhanced the healing process. For bone tissue engineering, 3D-printed aerogels featured an optimal porosity that promoted cell adhesion and migration.

Furthermore, $scCO_2$ can be employed for the green sterilization of aerogels, ensuring that their structural integrity and bioactivity are preserved during the process.

Keywords: biopolymer, supercritical CO_2, drug delivery, tissue engineering

Corresponding author email: claralopez.iglesias@usc.es

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ANTIOXIDATIVE POTENTIAL OF PLUM OIL-CAKE BASED BIOFILMS

***Pantić J.*[1], *Šuput D.*[1], *Hromiš N.*[1], *Popović S.*[1]**

[1] *Faculty of Technology Novi Sad, Bulevar Cara Lazara 1, 21 000 Novi Sad, Serbia*

Abstract

Plastics are among the most commonly used packaging materials today. The use of non-renewable sources for plastic production and the generation of large amounts of plastic waste are the main reasons why scientists are focussed on finding new environmentally friendly packaging materials. Biopolymers are the materials of the green era in food packaging as they are biodegradable and originate from renewable sources. On the other hand, modern technologies tend to utilise agro-industry waste, so various biomasses are being investigated in terms of valorization. The fruit industry produces huge amounts of fruit waste and by-products (pits, peels, stones, pomace, pulp, stems, leaves and stones), which are left behind. Fruit seed presents a nutritious raw material for value-added compounds extractions, as well as, for oil production. After cold pressing of oil seed, plum oil cake letfs behind as a nutritious by-product. Plum oil cake (POC) with its rich chemical composition presents valuable source for biofilms production. Thus, in this study plum oil cake was used to obtain biofilms by varying the process parameters: Glycerol content (10%, 20%, 30%) pH (8, 10, 12) and temperature (60 and 90 °C). POC films were characterized by examining the antioxidative properties (DPPH scavenging activity). The influence of process parameters on antioxidative capacity was examined. All biofilms exhibited high antioxidant activity, while the highest antioxidative activity (75.36%) had POC sample synthesized with 15% glycerol, on 90°C and pH 10. As the POC films revealed excellent antioxidative properties, they can be considered as an active biomaterial intended for food packaging and shelf life prolongation.

Keywords: plum oil cake, biofilms, antioxidative potential, active films, DPPH

Corresponding author email: jovana.ugarkovic@uns.ac.rs

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MECHANOCHEMICAL SYNTHESIS OF COVALENT TRIAZINE POLYMERS FOR POLLUTANT CAPTURE AND PLASTIC WASTE UPCYCLING

***Saeed Z.*[1], *Jadhav T.*[1], *Anjum D.*[2], *Mathew R.*[3], *Thomas B.*[3], *Mohamed S.*[1]**

[1] *Green Chemistry & Materials Modelling Laboratory, Department of Chemistry, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates*

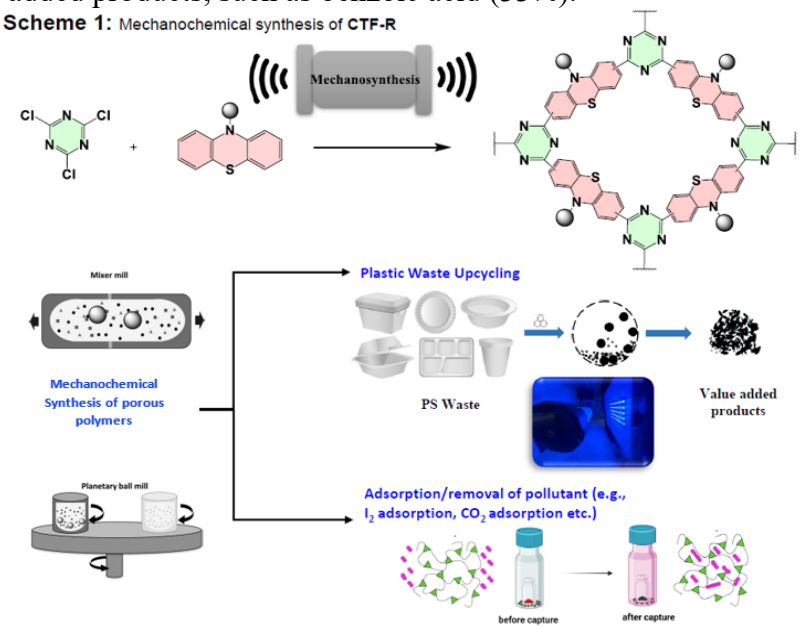
[2] *Department of Physics, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates*

[3] *Science Division, New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, United Arab Emirates.*

Abstract

Covalent triazine framework (CTFs) are a sub-category within the broader family of porous organic polymers, renowned for their outstanding stability and relatively low-cost production method. The synthesis of CTFs can be achieved through a direct Friedel-Crafts reaction. In this work, novel porous covalent triazine frameworks were synthesized via green mechanochemical methods. The mechanochemical methodology not only served as an eco-friendly and sustainable alternative to conventional method, but also facilitated the synthesis of products that are unachievable via solution-based methods. The novel polymer was characterized by SEM/TEM, FTIR, XPS, PXRD, UV-DRS, BET, ssNMR, and EPR. The investigated application for this polymer in adsorption included iodine vapor capture achieving a notable 314% uptake capacity, and CO_2 adsorption at 3.7 mmol/g. In addition, the polymer exhibited remarkable photocatalytic activity, achieving approximately 90% degradation of polystyrene and enabling the upcycling of plastic into value-added products, such as benzoic acid (33%).

Scheme 1: Mechanochemical synthesis of **CTF-R**



Keywords: Covalent Triazine Polymers, Porous organic polymer, Mechanochemistry, Plastic upcycling

Corresponding author email: †100049514@ku.ac.ae

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SUB-CELLULAR FIBRILLATION OF PLANT BIOMASS FOR SUSTAINABLE BIO-BASED MATERIALS DEVELOPMENTS

Tardy B.L.[1]

[1]*Department of Chemical and Petroleum Engineering, Khalifa University, Abu Dhabi, The United Arab Emirates*

Abstract

Sub-cellular fibrillation of plant cells has enabled the preparation of a wide range of nanocellulosic building blocks with diameters ranging from 4 to 60 nm and lengths from 0.2 to several micrometers, enabling the manufacture of new sustainable yet high performance materials. Nanocellulosic materials offer unique opportunities for advanced materials, while being central to the expansion of the circular bioeconomy (*Tardy et al., Nature Sustainability, 2023*).

In this talk, advances from the research team regarding the latter will be showcased in terms of high strength adhesives, with performance comparable to commercial, petrochemical-based adhesives, (*Tardy et al., Advanced Materials 2021*), ultrastable food-grade foams with up to 24h stability (*Abidnejad et al., ACS Nano 2022*), microbially synthesized materials exploiting chemical gradients (*Greca et al., ACS Nano, 2021*), and new soil amendment strategies enabling water and fertilizers' retention *(AlDali et al., Biomacromolecules, 2024)*. A discussion is then put forward on how advances in sub-cellular fibrillation of biomass could be associated with a better integration of arid areas in the global bioeconomy (*Tardy et al., ACS Sustainable Chemistry & Engineering 2023*). Recent results on the use of food waste and losses for the transformation of desertic soils into arable soils (*AlDali et al., Biomacromolecules 2024)*, and the use of coastal marine life for the preparation of high value products will be put forward.

In the long term, through developments of historically strong bioeconomies, the talk showcases that there is a large potential for traditionally dry regions to participate in the bioeconomy via more localized biomass generation and valorization strategies. A circular bioeconomy in arid area would address important challenges associated to food and (bio)materials supply and, ultimately, to climate and the environment.

Keywords: Nanofibrillation, Lignocellulose, Multi-scaled Materials, Arid Areas, Deserts Remediation.

Corresponding author email: blaise.tardy@ku.ac.ae

PLANT-BASED BIOMASS VALORISATION FOR THE DEVELOPMENT OF BIOPLASTIC FILMS USING NATURAL DEEP EUTECTIC SOLVENTS

Tzani A., Pitterou I., Chroni A., Georgiou V.A., Detsi A.

National Technical University of Athens, School of Chemical Engineering, Zografou Campus, 15780 Athens, Greece

Abstract

Chitosan, a copolymer of glucosamine and N-acetyl glucosamine, is derived from chitin (which is found in cell walls of crustaceans, fungi, insects, algae, etc) and consist an emerging key raw material for the development of various materials with numerous applications in food, pharmaceuticals, healthcare etc. The food industry is one of the main industries that use large amounts of plastics for packaging thus the renewable and sustainable alternatives in packaging and coating materials is of great interest. Chitosan-based films, possess desirable properties due to the natural origin and bioactivity of chitosan and have been studied as materials for food packaging applications. However, depending on the used plasticizer, chitosan films can be brittle with poor mechanical properties. The aim of this study is the development of chitosan-based films with advanced properties suitable for coating/packaging applications using Natural Deep Eutectic Solvents (NADES). NADES are green solvents derived from naturally occurring compounds which in specific molar ratios, exhibit a very low-temperature eutectic point. Biocompatible and task-specifically designed NADES have been recently used as plasticizers in order to improve the elasticity and reduce the fragility of chitosan films. In the present study, a task-specific NADES was synthesized and used for the ultrasound-assisted treatment of biomass derived from a plant material source in order to obtain an extract rich in cellulose. The as-obtained extract was then used as a multifunctional agent-as a plasticizer and mechanical properties enhancer-in order to prepare chitosan films using the casting method. The effect of the molecular weight of chitosan as well as the quantity of biomass used during the pretreatment process with the NADES on the mechanical properties of the chitosan films were investigated. The films were characterized using FT-IR spectroscopy, whereas their weight, thickness, elasticity, bristliness, and water vapor permeability were also evaluated. Overall, This study explores the use of plant-based biomass and task-specifically designed NADES to create novel bioplastics with improved properties suitable for coating applications. By aligning with green chemistry principles, this approach promotes sustainability and supports the goals of a circular economy.

Keywords: Natural Deep Eutectic Solvents, chitosan, bioplastics, biomass

Corresponding author email: atzani@mail.ntua.gr

MICROPARTICLES FORMULATIONS WITH 3-IN-1 EFFECT FOR PLANT NUTRITION AND PROTECTION

Vinceković M.[1]

[1]*University of Zagreb Faculty of Agriculture, Svetošimunska cesta 25, 10000, Zagreb, Croatia*

Abstract

The use of agrochemicals in agriculture has had significant environmental, food security, and human health impacts, primarily because some of these substances are persistent organic pollutants. To reduce overall exposure to agrochemicals that can contaminate the environment, there is a global push to limit their use and promote environmentally friendly alternatives such as biofertilizers and biopesticides (pesticides derived from natural materials). Biofertilizer formulations typically consist of living microorganisms (such as bacteria or fungi) combined with a suitable carrier and additives. A key challenge in formulation is selecting a carrier that can keep the microorganisms viable during storage and transport while maintaining their functional properties after application. Encapsulation in microparticles (microspheres or microcapsules) is an advanced technology that offers superior protection for living organisms, enhancing their viability and enabling controlled release into the field. Agricultural trends in encapsulation focus on developing microparticle formulations that include biological and chemical agents. The main challenges are (i) selecting microparticles capable of incorporating these agents and (ii) ensuring their coexistence does not reduce their effectiveness. Due to crop protection and nutrition benefits, *Trichoderma viride* spores (biofertilizers) and copper or calcium cations (micro- or macronutrients) were chosen as an ideal combination of chemical and biological agents. We developed and characterized alginate microspheres and microcapsules (coated with a chitosan layer) through ionic gelation using copper or calcium cations as crosslinking agents, loaded with *T. viride* spores. Simultaneous loading in microparticles showed that both *T. viride* spores and gelling cations retained their bioactivity when co-encapsulated. Controlled release—ensuring bioactive agents are delivered to plants at the optimal time—is a crucial feature for all delivery systems. To design an effective system for the simultaneous loading and release of bioactive agents at rates matching plant needs, it is important to optimize various parameters during microparticle preparation. Key factors include the concentration of the gelling cation, microparticle size, and the presence of a chitosan layer. Gelation at a constant sodium alginate level but varying gelling cation concentrations led to different kinetics and release mechanisms. Higher concentrations of gelling cations increased the release rate, while the addition of a chitosan layer and larger particle size slowed it down. Analysis using the Korsmeyer–Peppas model indicated that the release mechanism was influenced by gelling cation concentration, T. viride spores, and the chitosan coating. This research highlights that careful selection of formulation parameters is essential for designing microparticles capable of controlled release of biofertilizers and nutrients for plant protection and growth.

Keywords: encapsulation, formulations, agroecological, protection, nutrition

Corresponding author email: mvincekovic@agr.hr

4. Green solutions in development of biopolymers and advanced materials

Flash oral presentations

FEASIBILITY ASSESSMENT OF EXPANDING SUPERCAPACITOR PRODUCTION USING GRAPHENE OXIDE AND SEQUENTIAL HTC-ACTIVATION PROCESSES

***Arauzo P.J.*[1], *Checa-Gómez M.* [1], *Sangam K.P.* [1], *Kruse A.* [1]**

[1]*Department of Conversion Technologies of Biobased Resources, Institute of Agricultural Engineering, University of Hohenheim, Garbenstrasse 9, 70599 Stuttgart, Germany*

Abstract

The recent surge in interest in activated carbon (AC) has been largely driven by its extensive range of applications, particularly in the environmental and energy sectors. The amalgamation of graphene oxide and residues derived from food waste presents enhanced properties that offer promising viable solutions in areas such as water purification, gas adsorption and energy storage. The combination of food waste-based precursors and graphene oxide not only optimizes the material's surface area and porosity, but also introduces functional groups that improve its adsorption capacity, indicating a significant improvement in the material's performance. AC is typically produced through thermal treatments such as physical (e.g. H_2O steam or CO_2) or chemical activation (e.g. KOH, H_3PO_4, $ZnCl_2$). The carbon rich material properties can be fine-tuned by modifying the feedstock, activation process, and post-treatments, allowing it to be tailored to meet specific goals for different applications.

The objective of this study is to gain a deeper understanding of the impact of consolidating graphene oxide, model food waste materials (i.e. cellulose and chitosan) and brewer´s spent grains under hydrothermal carbonization (240 °C and 2 hours) and physical activation process conditions (750°C and 30 min), using water-steam as an activating agent. The relevant activated carbon physicochemical properties were measured, Raman, SEM-EDX, pH, specific surface area, FTIR and thermal stability. The results of the product yield with the nitrogen recovery comparisons under different conditions are presented in order to provide a comprehensive overview of the process.

The potential of retaining nitrogen in the material without combining it with graphene oxide was observed. The Raman analysis shows that the steam activation involves the heating of the hydrochar at elevated temperatures in the presence of the H_2O steam as oxidizing agent, results in the removal of volatile components, enhancement of porosity, and promotion of the formation of more ordered carbon structures. The SEM images illustrated the hydrochar's surface covered with small carbon microspheres and fragmented particles, suggesting a low porous structure. In contrast, AC exhibited a heterogeneous cracked surface with well-developed pores as a result of physical activation with H_2O steam.

Keywords: Bio-waste, HTC, activated carbon, supercapacitor's electrode, pore size distribution

Corresponding author email: pabloj.arauzo@uni-hohenheim.de

SYNERGY OF PLASTIC WASTE, CONSTRUCTION WASTE FROM DEMOLITION AND OTHER INDUSTRIAL WASTE FOR MAKING SIDEWALKS AND BICYCLE PATHS 100% RECYCLED- PROJECT INTRODUCTION

***Chowaniec-Michalak A.*[1], *Chajec A.*[1], *Borowczak M.*[1], *Krzywiński K.*[1], *Sobczyk K.*[1], *Czarnecki S.*[1]**

[1]*Wroclaw University of Science and Technology, Faculty of Civil Engineering, Department of Materials Engineering and Construction Processes, pl. Grunwaldzki 11, 50-377 Wroclaw, Poland*

Abstract

The Project fits into the idea of construction 5.0. and circular economy. Currently, some of the least used waste is construction waste, and there will be even more of it, as in the European Union alone just over 20% of residential buildings were built before 1946. These facilities will generate a significant amount of waste, but also a potential raw material for reuse as surface materials. Plastic waste is also underutilized, with only 40% recycled in the EU. By combining construction and plastic waste, the project aims to produce composite materials for sidewalks and bike paths. This is in response to growing global plastic production, which reached over 390 million tons annually by 2021, a 260-fold increase since 1950. Although plastic production in Europe is systematically decreasing, it was still around 56 million tonnes last year. Long-term projections estimate global production could reach 33 billion tons by 2050, marking a significant rise over the next 25 years. There are no comprehensive solutions in the scientific and technical literature aimed at determining the potential of using waste from the demolition of buildings and plastics as a source of raw materials and matrices that can be used to produce new products. The main goal of the project is to develop a technology for producing small-sized – in construction, i.e., a few or a dozen centimetres in size – building elements made of a composite consisting of a binder in the form of waste plastics and, as an aggregate, construction waste from demolition and other industrial waste. The application also aims to develop technologies for producing surface materials. As part of the research, the material composition and production technology of these materials will be developed. Moreover, the composite itself from which they will be made can be reused. This will significantly reduce the carbon footprint and life cycle costs of these structures. In turn, the aspect of securing supplies and critical technology for manufacturing processes is ensured by two components, which are materials available practically everywhere in the European Union. The developed production technology will be able to be used in regional waste management enterprises, which increases the commercialization potential of the project. In this way, a global problem can be solved by local action, potentially reducing the costs of transporting such material.

Keywords: Construction waste, Building composites, Plastics, Cycle paths, Pathways

Corresponding author email: agnieszka.chowaniec@pwr.edu.pl

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ACTIVATED CARBON-DECORATED ELECTROSPUN FIBERS AND THEIR APPLICATION IN AIR FILTRATION

Czerwinska N., Generosi N., Giosue' C., Luzi F., Corinaldesi V., Ruello M.L.

Department of Materials, Environmental Sciences and Urban Planning (SIMAU), Polytechnic University of Marche, Ancona, Italy

Abstract

From a circular economy perspective, this research aims to develop a new filtering system for air purification for domestic kitchen hoods devices in domestic environments capable of responding to the needs related to the sustainability of the materials used and the confined environment to be purified. For this purpose, special attention was paid to the materials used to produce fine nanofibers, biodegradable and derived from the upcycling of agricultural waste. Eco-friendly polylactic acid (PLA) and spent coffee grounds-derived activated carbon (AC) hybrid filters were prepared via electrospinning method.

Air filters are crucial components of a building ventilation system and kitchen hoods that contribute to improve indoor air quality. Electrospinning, which is a simple and low-cost method of synthesis of nanofibers, guarantees excellent filtering performance of the obtained membranes by removing particulate matter (PM) produced during cooking. Compared to the conventional air filter media like glass fibers and melt-blown fibers, the electrospinning membranes are more efficient for capture various pollutants due to the smaller pores. By functionalization electrospun fibers using AC, odor pollutants like Volatile Organic Compounds (VOCs) can be trap.

Physio-chemical properties and morphology of obtained filters were characterized by TG, FTIR, SEM, N_2 adsorption-desorption isotherm analysis. Filtering efficiency and adsorption properties were evaluated in pilot-scale room by measuring the filter penetration of new-synthesized and commercial filters, against neutralized aerosol particles (2% NaCl) and VOC (Methyl Ethyl Ketone). Our results demonstrate that combination of both filtration and adsorption mechanisms in proposed hybrid membranes, would be promising materials for highly efficient and sustainable air filters for home appliance systems.

Keywords: Depollution, VOCs adsorption, Indoor Air Quality, Electrospinning

Corresponding author email: n.czerwinska@staff.univpm.it

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NANOSTRUCTURED LIPID CARRIERS AND NATURAL DEEP EUTECTIC SOLVENTS: A HIGHLY ADVANTAGEOUS COMBINATION FOR THE ENCAPSULATION OF CURCUMIN

***Safari K.*[1], *Pitterou I.*[1], *Apostolopoulos A.*[1], *Tzani A.*[1], *Detsi A.*[1]**

[1]*Laboratory of Organic Chemistry, School of Chemical Engineering, National Technical University of Athens, 9 Heroon Polytechniou Str., 15780, Athens, Greece*

Abstract

Curcumin ((1*E*,6*E*)-1,7-Bis(4-hydroxy-3-methoxyphenyl)hepta-1,6-diene-3,5-dione) is a naturally occurring polyphenol with known antioxidant activity, however its hydrophobic nature often deters its exploitation due to low solubility and bioavailability. These limitations can be addressed and overcome by encapsulating curcumin in appropriate drug carriers, with nanoparticle-based formulations being the most promising and effective approach.

Nanostructured Lipid Carriers (NLCs) have emerged as a new generation of lipid nanoparticles, which are employed as encapsulation matrices and drug delivery vehicles for bioactive substances. NLCs combine solid lipids and liquid lipids (oils) in their structure, leading to enhanced properties for drug delivery applications.

The aim of the present study is the development and optimization of a greener methodology for the preparation of NLCs and, subsequently, the encapsulation of curcumin, by incorporating Natural Deep Eutectic Solvents (NADESs). NADESs are defined as eutectic liquid mixtures of two or more solid or liquid components of natural origin, a hydrogen bond donor (HBD) and a hydrogen bond acceptor (HBA). NADESs display a vast range of advantages such as biodegradability, biocompatibility, non-volatility, non-flammability, low toxicity and low cost, rendering them an eco-friendly alternative to conventional organic solvents, which are often detrimental to human health and the environment.

The use of hydrophobic NADESs in the preparation of NLCs is an innovative and advantageous approach, since they act both as a solvent for curcumin and as the liquid lipid for the NLCs.

In this context, a hydrophobic NADESs was synthesized and characterized, and the solubility of curcumin in the NADES was studied. The NADES was then incorporated in the NLCs, successfully acting as the “liquid lipid”. The NLCs were evaluated on their encapsulation efficiency, size, polydispersity index and zeta potential, while their antioxidant ability (DPPH free radical scavenging ability and lipid peroxidation inhibitory activity) were also determined.

Keywords: Natural Deep Eutectic Solvents, Nanostructured Lipid Carriers, Curcumin

Corresponding author email: kiarasafari@gmail.com

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4. Green solutions in development of biopolymers and advanced materials

Posters

ANALYSIS OF PHBV (POLY(3-HYDROXYBUTYRATE-CO-3-HYDROXYVALERATE)) AND OTHER BIOPOLYMERS BY GC-MS

***Aladić K.*[1], Kučić Grgić D.[2], Jozinović A.[1], Šubarić D.[1], Strelec I.[1], Ocelić Bulatović V.[2], Opačak K.[1], Jokić S.[1]**

[1]*Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia*
[2]*University of Zagreb Faculty of Chemical Engineering and Technology, Marulićev trg 19, 10000 Zagreb, Croatia*

Abstract

The global trend toward biodegradability has led to the production of biopolymers incorporated into new packaging materials. Certain microorganisms possess the ability to produce these biopolymers, prompting the development of methods to optimize biomass production, maximizing the amount of polymer generated from food industry by-products used as raw materials. Additionally, it is essential to monitor the composition of the produced biopolymer to ensure the highest possible purity. This work focuses on developing a method necessary for detecting the types of biopolymers formed within microbial cells. Gas chromatography coupled with mass spectrometry has proven to be an effective analytical technique for determining biopolymers. To identify the type of polymer produced, the extracted polymer must undergo acid hydrolysis, which will depolymerize it into its basic building units (methyl (R)-3-hydroxyvalerate). In conclusion, gas chromatography is essential for analysis during biopolymer production.

Keywords: biodegradation, PHBV, GC-MS

Corresponding author email: kaladic@ptfos.hr

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IMPACT OF NATURAL PRESERVATIVES ON THE QUALITY AND SHELF-LIFE OF RICOTTA CHEESE

Lima L.[1,2,3,4], Pereira A. I.[3], Pintado M.[4], Carocho M.[1,2]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[2]Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[3]Centro de Investigação em Digitalização e Robótica Inteligente (CeDRI), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[4]Centro de Biotecnologia e Química Fina (CBQF), Associated Laboratory, School of Biotechnology, Catholic University of Portugal, 4169-005 Porto, Portugal

Abstract

This study evaluates the effectiveness of natural preservatives in extending the shelf life of fresh ricotta cheese through physicochemical analyses and nutritional characterization over time. The research focuses on natural extracts derived from agro-industrial by-products rich in phenolic compounds and antioxidants, assessing their potential to maintain product quality and prolong shelf-life without compromising sensory attributes. Optimized extracts from tangerine peel, grape seeds, and corn silk were incorporated into ricotta cheese samples. During storage (14 days), physicochemical parameters were monitored, including pH, moisture content, color, texture, and nutritional composition (total fat, protein, ash, and carbohydrate content). Results revealed that grape seed extract had significant impact, reducing fat content by 10.8%, but causing a protein loss of 9.5%. In contrast, corn silk extract was effective at preserving fat (with only a minimal reduction of 1.1%) but resulted in a more pronounced protein reduction (13.2%) and moderately affected physicochemical properties. Tangerine peel extract emerged as the most effective preservative, showing moderate reductions in fat (5.5%) and protein (8.1%) while maintaining nutritional balance throughout the storage period. Compared to the other preservatives, tangerine peel extract preserved both the physicochemical and nutritional properties more consistently, ensuring the highest quality of the cheese over the shelf life. Thus, this research provides a sustainable alternative for preserving fresh cheeses using natural preservatives, contributing to the valorization of agricultural waste and promoting sustainability in the food industry. Future studies will include monitoring volatile compound content and microbial load during storage to evaluate the impact of these extracts on microbiological safety.

Keywords: Natural preservatives, Shelf-life, Ricotta cheese.

Corresponding author email: mcarocho@ipb.pt

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DEVELOPMENT OF A SUSTAINABLE MEDITERRANEAN-INSPIRED SNACK: GREEN EXTRACTION OF BIOACTIVE COMPOUNDS AND BIOPOLYMER PACKAGING

Lopes J.K.[1,2,3], Heleno, S.A.[1,2], Roriz C.L.[1,2], Prieto M.A.[3], Carocho M.[1,2]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[2]Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[2] Nutrition and Bromatology Group, Department of Analytical Chemistry and Food Science, Instituto de Agroecoloxía e Alimentación (IAA)–CITEXVI, Universidade de Vigo, 36310 Vigo, Spain

Abstract

The Mediterranean diet, well known for its health benefits, is characterized by high consumption of plant-based foods, along with low to moderate amount of seafood and animal products. In contrast, life in the 21st century is marked by a fast-pace, making the consumption of nutritious foods challenging, as ultra-processed foods have become the default option for their convenience, despite their negative impact on health.

The *MedSnack* project appears as an alternative, by developing a minimally processed and sustainable ready-to-eat snack, incorporating the nutritional value of the Mediterranean diet by using olives and dates, sweetened with honey, and enhanced with natural colorants and bioactives. The wrapper of the snack will be produced from algae-based polymers, infused with volatile protective compounds obtained from the bioresidues of olive and date trees, through innovative and sustainable processes like ultrasound and microwave assisted extractions.

A key innovation of *MedSnack* is its sustainable and circular solution by using Mediterranean products and their residue to create a ready to eat, healthy, and sustainable product. This project is included in a wider funded PRIMA project, FoWRSaP – Agro Food Waste Recovery: New Processing Technologies for Food Safety and Packaging, aimed at adding value to residues to develop new packaging and improve food safety in several food products.

Keywords: Mediterranean diet, ready-to-eat, sustainable packages, bioresidue

Corresponding author email: mcarocho@ipb.pt

Acknowledgements: This work was supported by national funds through FCT/MCTES (PIDDAC): CIMO, UIDB/00690/2020 (DOI: 10.54499/UIDB/00690/2020) and UIDP/00690/2020 (DOI: 10.54499/UIDP/00690/2020); and SusTEC, LA/P/0007/2020 (DOI: 10.54499/LA/P/0007/2020). Carocho M. thanks Fundação para a Ciência e a Tecnologia for his research contract (CEEC-IND/00831/2028). Lopes J.K. thanks PRIMA/004/2023 (doi.org/10.54499/PRIMA/0004/2023) FoWRSaP project for his PhD grant.

BIODEGRADABLE BIOPOLYOLS IN THE FORMULATION OF FLEXIBLE POLIURETHANE FOAMS

***Castano-Forte C.*[1], *Munoz-Martí M.*[1], *Navarro-Bañón M.V.*[1], *Candela-Gil A.*[1]**

[1]*Technology Centre of Furniture and Wood of the Region of Murcia (CETEM), Perales, 30510 Yecla, Murcia, Spain*

Abstract

Flexible polyurethane foams (FPUF) are a widely used material in different industrial sectors such as cushioning, padding or insulation materials. Approximately 675,000 tons of waste from these foams are generated annually in Europe and that means a problem due to their recalcitrant nature. The recycling of this material aims to reduce waste or give it a second life, minimizing the environmental impact and the accumulation of waste in landfills. Among the recycling techniques, biological recycling has gained considerable attention in recent years for flexible polyurethane foams, due to it is showing encouraging results, especially with certain microorganisms and enzymes capable of attacking polyurethane and degrading it.

From a chemical point of view, we can modify the material to make it more biodegradable at the end of its useful life. The aim of this work was to analyse the effect of adding biopolyol with biodegradable properties in FPUF formulations and on their final chemical, physical and mechanical properties. For that, a biobased polyol proceed from plant matter was used (specially Merginol®). Mixtures were prepared with different percentages of conventional polyol substituted with biopolyol to be used in the FPUF formulations, and the physical properties were analysed. The mixing conditions and the other components used were kept consistent across all formulations.

The results showed that a 30wt% of biodegradable biopolyol can be added in FPUF formulation and a cellular material with acceptable physicomechanical properties was obtained. Furthermore, the incorporation of biopolyol imparts a certain degree of biodegrability to the resulting FPUF materials. Therefore, the use of polyols of biological origin and with biodegradable properties appears to be a promising alternative to the polyols traditionally used to manufacture FPUF, because they allow materials with similar physical properties but better degradation at the end of their useful life.

Keywords: Biopolyol, FPUF, Biodegradation.

Corresponding author email: c.castano@cetem.es

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BIODEGRADABLE PACKAGING MATERIALS BASED ON POLY(VINYL ALCOHOL) AND LIGNIN - SUSTAINABLE APPROACH TOWARD GREEN ECONOMY

***Goliszek-Chabros M.*[1], *Podkościelna B.*[2] , *Xu T.*[3], *Sevastyanova O.*[3,4]**

[1] Analytical Laboratory, Institute of Chemical Science, Faculty of Chemistry, Maria Curie-Skłodowska University, M. Curie-Skłodowska Sq. 3, 20-031 Lublin, Poland;
[2] Department of Polymer Chemistry, Institute of Chemical Science, Faculty of Chemistry, Maria Curie-Skłodowska University, M. Curie-Skłodowska Sq. 5, 20-031 Lublin, Poland;
[3] Wallenberg Wood Science Center, Department of Fiber and Polymer Technology, School of Chemistry, Biotechnology and Health, KTH Royal Institute of Technology, Teknikringen 56-58, 100 44 Stockholm, Sweden;
[4]Division of Wood Chemistry and Pulp Technology, Department of Fiber and Polymer Technology, School of Chemistry, Biotechnology and Health, KTH Royal Institute of Technology, Teknikringen 56-58, 100 44 Stockholm, Sweden.

Abstract

Environmental pollution of non-degradable packaging and the increasing demand for biodegradable packaging materials are driving research on the design and development of multifunctional polyvinyl alcohol (PVA)-based films. Poly(vinyl alcohol) (PVA) is a type of water-soluble biodegradable polymer, which has attracted particular interest for advanced multifunctional packaging industry, principally owing to its non-toxic, outstanding biodegradability, high transparency, and excellent oxygen barrier performance. On the other hand, due to the depletion of fossil fuels there is an urgent need to develop technologies using renewable raw materials as feedstock. The total or partial replacement of fossil-derived polymer precursors with renewable, bio-based feedstocks is one route to improve the sustainability of these products. Lignin is the second most abundant biomass resource from plants, which has attracted unusual attention for its low-cost, non-toxic, biodegradability and UV-shielding performance. Although a large amount of industrial lignin is produced every year, it is mostly burned as low-value fuel, leading to severe resource waste. Exploiting the rational utilization of lignin for PVA composites is a feasible strategy for biomass utilization. The aim of this work is the valorisation of lignin of different origin (spruce and eucalyptus) as additives in polymer films based on PVA. The outcome is deemed to aid developing novel PVA-based for biodegradable packaging materials and UV-shielding packaging materials, and it provides a way to solve the pollution of non-degradable plastics. This research work focuses on the significant issue of sustainable solid waste management through the promotion of safe practices and effective technologies, aiming to accelerate the transition to the circular economy.

Keywords: circular economy, sustainable development, lignin, waste valorization

Corresponding author email:marta.goliszek@mail.umcs.pl

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PREPARATION AND CHARACTERIZATION OF CHITOSAN-BASED EDIBLE FILMS REINFORCED WITH PEACH PEELS EXTRACT AS ACTIVE PACKAGING MATERIALS

Kyriakoudi A., Loukri A., Christaki, S., Goutlis A., Mourtzinos I.

Laboratory of Food Chemistry and Biochemistry, Department of Food Science and Technology, School of Agriculture, Faculty of Agriculture, Forestry and Natural Environment, Aristotle University of Thessaloniki (AUTH), 54124, Thessaloniki, Greece;

Abstract

Disposal of wastes from non-degradable food packaging materials from petroleum-derived resources, such as polyethylene and polystyrene, is a serious problem worldwide. This has led the scientific community to develop biodegradable materials in order to minimize environmental impact, such as the case of biopolymer-based edible films. The use of the latter in order to prevent lipid oxidation in foods, development of off-flavors and nutritional losses, organoleptic changes due to microorganisms proliferation as well as to extend self-life and improve the quality of fresh, frozen and processed foods, are of great importance taking into account consumers' health concerns. The biopolymer chitosan, derived from the deacetylation of chitin, is commercially used in the food and pharmaceutical sectors due to its physical, chemical and biological properties. It is biodegradable, nontoxic, and biofunctional, and it possesses biocompatible properties. By reinforcing chitosan films with extracts from by-products of the agrofood sector, their mechanical and barrier properties can be significantly enhanced. This innovative approach not only provides a sustainable alternative to plastic packaging but also promotes the valorization of agroindustrial wastes, reducing food industry by-products and contributing to a circular economy. In this view, the aim of the present study was the preparation of chitosan-based edible films reinforced with peach (*Prunus persica* L.) peels extract as well as their physicochemical characterization in terms of thickness, color, UV–vis light barrier property, moisture content and water solubility, Water vapor permeability, mechanical properties as well as antioxidant activity. The proposed methodology could be utilized towards the development of innovative and environmentally-friendly active packaging materials.

Keywords: chitosan films, active packaging materials, peach peels extract, mechanical properties, physical properties

Corresponding author email: mourtzinos@agro.auth.gr

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NEW HIGH SURFACE AREA MESOPOROUS SILICA NANOPARTICLES AND ITS USE TOWARDS ANTIFOULING MATERIALS

***Gruttadauria M.*[1,2], *Marzullo P.*[1,2], *Campisciano V.*[1], *Giacalone F.*[1], *Presentato A.*[1], *D'Anna F.*[1], *Liotta L.F.*[3]**

[1] *Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEF), University of Palermo, Viale delle Scienze, 90128 Palermo, Italy*
[2] *Sustainable Mobility Center (Centro Nazionale per la Mobilità Sostenibile—CNMS), Via Durando 39, 20158 Milano, Italy*
[2] *Institute for the Study of Nanostructured Materials (ISMN), (Italian) National Research Council (CNR), Via Ugo La Malfa 153, 90146 Palermo, Italy*

Abstract

Green and sustainable materials towards new antifouling materials is a topic of great interest. Amorphous silica nanoparticle materials are of interest due to their potential use in catalysis and biomedicine, such as cancer treatment and drug delivery applications. To these and other application, many efforts are devoted to the development of silica gel for new antifouling materials. Amorphous silica materials can be obtained by the conventional sol–gel route starting with tetraethoxysilane, and can give silica with a wide pore size distribution. However, the pores can be tuned by the conventional organic template-assisted sol-gel process, where the silica gel structure is trapped with organic molecules. Removal of the organic template by calcination results in porous silicate networks with pores affected by the template molecules.
Here we describe the synthesis of an amorphous silica with very high surface area (1000 m^2/g) and narrow pore size distribution obtained using resorcinol as template. The very simple and economic strategy makes this approach interesting. Then, to evaluate the usefulness of the new silica gel we planned the grafting of a suitable molecule, an alkoxysilane, onto this silica to obtain a material with antifouling activity.
To do this, we first synthesized a set of quaternary ammonium salts-based silanes, and the antibacterial activity of these molecules was tested against *Pseudomonas delhiensis PS27*. The most active compound was grafted on the surface of the silica gel and a very good antibiofilm activity was observed.
As a future application, the new silica gel will be modified to obtain new catalytic materials.

Keywords: antifouling, nanoparticles, silica gel.

Corresponding author email: michelangelo.gruttadauria@unipa.it, paola.marzullo@unipa.it

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BIODEGRADABILITY OF BIOPOLYMERIC BLENDS COMPOSED OF THERMOPLASTIC STARCH AND POLYLACTIDE

***Jozinović A.*[1], Kovač M.[2], Ocelić Bulatović V.[3], Šubarić D.[1], Jokić S.[1], Aladić K.[1], Babić J.[1], Ačkar Đ.[1], Kučić Grgić D.[3]**

[1]*Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia*
[2]*University of Mostar, Faculty of Agriculture and Food Technology, Biskupa Čule bb, 88000 Mostar, Bosnia and Herzegovina*
[3]*University of Zagreb Faculty of Chemical Engineering and Technology, Marulićev trg 19, 10000 Zagreb, Croatia*

Abstract

Biodegradation is the chemical decomposition of materials in which microorganisms break down organic matter. The process is irreversible and causes structural changes and loss of material properties. In the framework of this research, a mixture of thermoplastic starch (TPS) and polylactide (PLA) of different composition was prepared, with and without the addition of citric acid (CA). Since the nature of starch is hydrophilic, while PLA is hydrophobic, combining them can result in a low degree of miscibility. In order to improve the interfacial interaction and promote the mixing of these two biodegradable polymers, compatibilizers, such as citric acid, were added. In this study, starch was isolated from the Scala potato variety, which was then processed into TPS by extrusion with glycerol as a plasticizer, without and with 5, 10 and 20% of CA. A blends of TPS and PLA of different composition was prepared, with and without the addition of CA. Different combinations of TPS/PLA and TPS-citrates/PLA were prepared in the ratios of 40:60, 50:50 and 60:40. The biodegradation of polymer blends was investigated. The analysis of the biodegradability of the material was carried out in accordance with the standards ISO 14855 and ASTM D5338. According to the results, it was observed that TPS degrades much faster compared to PLA and investigated blends, creating porous places or cavities in its structure. By analyzing the change in mass during the 7th, 14th, 28th, 42nd and 56th days of the biodegradation process, a comparison of the mass between TPS, PLA and prepared blends was made. The obtained results confirm the existence of a gradual degradation of TPS, while PLA did not degrade within the specified time period. Finally, it can be concluded that the addition of TPS accelerate the decomposition of PLA, as well as it reducing materials costs due to the high price of PLA.

Keywords: biodegradation, thermoplastic starch, polylactide, citric acid, polymer blends

Corresponding author email: ajozinovic@ptfos.hr

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INNOVATIVE NANOCOMPOSITE HYDROGELS FOR PHOTODYNAMIC THERAPY (PTD): SYNTHESIS AND APPLICATION

***Kalogeropoulou F.*[1], Pitterou I.[1], Spyropoulou K.[1], Alexandratou E.[2], Detsi A.[1]**

[1]*School of Chemical Engineering, National Technical University of Athens, Iroon Polytechniou 9, 15772 Athens, Greece*
[2] *School of Electrical Engineering, National Technical University of Athens, Iroon Polytechniou 9, 15772 Athens, Greece*

Abstract

Photodynamic therapy (PDT) is a therapeutic method that uses a photosensitizer, which, after irradiation with an appropriate light source and in the presence of oxygen, produces reactive oxygen species (ROS) leading to cell death. Hydrogels are hydrophilic colloidal polymeric networks that absorb large quantities of water or biological fluids, making them suitable for various applications.

This study presents the development of an *in situ* synthesis process of silver nanoparticles (AgNPs) in alginate hydrogels under sunlight, utilizing a Natural Deep Eutectic Solvent (NADES) composed of glucose, lactic acid, and water. NADES was used to extract bioactive compounds from olive leaves, and the extract was studied as a reducing, capping and cross-linking agent. The ability of the hydrogel-released nanoparticles to generate free radicals was examined, highlighting their potential as photosensitizers in PDT.

The nanocomposite hydrogels were characterized for their swelling capacity and water retention at pH 7.4. Hydrogels prepared with NADES showed a swelling of 617% of the initial dry mass at 15 min, decreasing to 155% after 210 min. Hydrogels prepared with NADES- olive leaf extract presented a swelling of 437% at 15 min, reaching a maximum of 584% at 135 min, and maintained 423% swelling at 210 min. These results suggest that NADES and NADES-extracts affect the hydrogel's mechanical properties differently, likely due to the polar nature of the bioactive compounds enhancing water retention. Furthermore, AgNPs released from the alginate hydrogel with olive extract demonstrated the highest ROS generation capacity compared to those without the extract. This indicates a significant potential for using these hydrogels in photodynamic therapy.

Keywords: Silver Nanoparticles, Hydrogels, PDT, ROS Production.

Corresponding author email: florakalo@gmail.com

PLANT-BASED BIOPOLYMERS AS CARRIERS OF TART CHERRY POLYPHENOLS

***Kopjar M.*[1], Buljeta I.[1], Pichler A.[1], Šimunović J.[2]**

[1] *Josip Juraj Strossmayer University, Faculty of Food Technology Osijek, F. Kuhača 18, 31000 Osijek, Croatia*
[2] *North Carolina State University, Department of Food, Bioprocessing and Nutrition Sciences, Raleigh, North Carolina, USA*

Abstract

Recently, the formulation of plant-based functional food additives has been the target of many studies. Proteins, as valuable plant biopolymers, can be used for the formulation of such additives in combination with polyphenols. Polyphenols are recognized for their many health-promoting properties but also their high instability, thus significant efforts are made to overcome this obstacle in the form of complexes with biopolymers. In this research, we used pea (85% of proteins), rice (85% of proteins) or almond (50% of proteins) protein matrices in combination with tart cherry juice to investigate if these matrices can be used as efficient biopolymers for adsorption of polyphenols. Obtained complexes were evaluated for total polyphenols, proanthocyanidins, and antioxidant potential by spectrophotometric analysis, and for individual polyphenols by HPLC. Additionally, IR spectra screening of complexes was conducted to evaluate changes in biopolymers structure. Adsorption capacities (AC) of polyphenols were calculated for each protein matrix and it was determined that AC declined in the following order rice protein matrix (RP) > pea protein matrix (PP) > almond protein matrix (AP). However, comparing AC for individual polyphenols different trends were observed depending also on the polyphenol type. Regarding individual polyphenols, in the tart cherry juice and on complexes following polyphenols were identified: cyanidin-3-glucosyl-rutinoside, cyanidin-3-rutinoside, quercetin-3-rutinoside, quercetin, neochlorogenic acid, *p*-coumaric acid and its derivate. While the quercetin was adsorbed completely by all protein matrices, that was not the case for other polyphenols. For both anthocyanins, AC declined in the following order PP > RP > AP, for quercetin-3-rutinoside PP = RP > AP and for neochlorogenic acid RP > PP > AP. Coumaric acid and its derivate had the highest AC on the almond protein matrix. Comparing IR spectra of complexes with corresponding protein matrix it was determined that hydrophobic interaction occurred during complexation between polyphenols and protein matrix. In addition, changes in specific amid structures of proteins occurred. Since the almond protein matrix contained fibers next to proteins, changes connected to polysaccharide structures were observed. This complexation can be perceived as a green approach in the formulation of functional food additives, which can be further used to forficate products with polyphenols and proteins.

Keywords: tart cherry polyphenols; pea, rice and almond protein matrices; adsorption

Corresponding author email: mirela.kopjar@ptfos.hr

ENVIRONMENTAL ISOLATION OF POLYURETHANE BIODEGRADING MICROORGANISMS AND DETERMINATION OF THEIR BIODEGRADATION CAPACITY

***Munoz-Martí M.*[1], *Navarro M.V.* [1], *Candela A.* [1], *Castaño C.* [1], *Castillo M.A.* [2], *García-Hernández J.* [2]**

[1] *Technology Centre of Furniture and Wood of the Region of Murcia (CETEM), Perales, 30510 Yecla, Spain*
[2] *Advanced Center of Food Microbiology (CAMA) of Polytechnic University of Valencia, Camí de Vera, 46022 València, Spain*

Abstract

Polyurethane (PU) is a versatile polymer extensively used in everyday products and different industries. However, the lack of sustainable waste management solutions, especially for PU foams, entail a significant environmental challenge. For instance, end-of-life mattresses are commonly incinerated or sent to landfills. In the last decades, several studies have focused on investigating innovative methods for efficient PU degradation and valorisation. One promising approach is the isolation of novel degradative microorganisms from different sources. The aim of the present study was to identify new PU-degradative strains accessing waste accumulation areas to isolate promising microorganisms in the PU waste valorisation.

A specific procedure was designed to select microorganisms with the capacity to degrade PU from environmental samples. Four waste accumulation areas were accessed, collecting soil samples and PU foam waste pieces. The samples were incubated in a saline medium supplemented with an aqueous PU dispersion (MM-PU). Next, serial dilutions of the cultures were inoculated in MM-PU agar plates and incubated until growth was observed. Colonies with a halo around them, indicating degradation of the PU present in the medium, were selected to obtain pure cultures. In addition, the PU degradation capacity of the isolates was determined using an absorbance measuring method based on the characteristic of commercial aqueous PU dispersion, which become transparent when degraded.

A total of 48 isolates showing evidence of PU biodegradation were obtained. After the establishment of pure cultures, the isolates were classified as bacteria or fungi and morphologically and biochemically characterized. Eighteen isolates showed significant PU biodegradation capacity (above 30%) when cultured in liquid MM-PU, being two filamentous fungi and sixteen bacteria. Six of these bacteria achieved PU-biodegradation rates higher than 75%.

Keywords: Biodegradation, Polyurethane, Environmental

Corresponding author email: m.munoz@cetem.es

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5. Advanced CO_2 capture and utilization

Oral presentations

TRANSMIT COST ACTION – A NETWORK FOR CARBON CAPTURE AND STORAGE AND DIRECT AIR CAPTURE TECHNO-ECONOMIC ANALYSIS

Skorek-Osikowska A. [1]

[1] *Silesian University of Technology, Akademicka 2A, 44-100 Gliwice, Poland*

Abstract

The main aim of this paper is to present the main goals and challenges of the Techno-economic analysis of carbon mitigation technologies (TrANsMIT), Cost Action number CA21127, as well as its achievements after two years of duration. TrANsMIT relates to the techno-economic analysis (TEA) of the overall, integrated CO_2 Capture, Utilisation, and Storage (CCUS) value chain. It aims to bring together academia, research institutes and industry into a cutting-edge, pan-European knowledge network. The Action advances the research frontier of CCUS TEA from partially unharmonized and disciplinary research to harmonized, holistic pan-European, coordinated research on the full CCUS system, facilitating development of the most technologically, economically and commercially feasible CCUS technologies and systems. It will be achieved by harmonizing and coordinating the methods and tools used for CCUS TEA in Europe, leveraging the knowledge created by our partners in national or international research projects. The project focuses most on holistic assessment of the CCUS chain, and on those areas where most development is needed (e.g. CO2 capture from air, CO2 utilization). The created science will be an essential means to steer CCUS R&D and deployment in a direction that allows reaching climate targets on-time and in a cost-effective manner, while harnessing the competitiveness of European industry. TrANsMIT will have a strong focus on knowledge sharing and career development, tackling existing disparities in knowledge distribution and career opportunities. It will foster strong collaboration between the more and the less research intensive countries in Europe, improving the access of the latter to State-of-the-Art science and new research projects. It will put into leadership roles early-career researchers and minorities, helping to fast-track their career development. TrANsMIT will lead to top-tier techno-economic analysis of CCUS systems across European countries.

Keywords: CO_2 capture, utilization and storage; DACs, NETs, Process modelling, Techno-economic analysis

Corresponding author email: anna.skorek@polsl.pl

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CO_2 SEQUESTRATION USING INNOVATIVE SOLVENTS BASED ON THE USE OF METAL OXIDE NANOPARTICLES

Chillè A.[1]

[1] *Sapienza University of Rome, Dept. of Chemical Engineering Materials Environment, via Eudossiana 18, 00184, Rome, Italy*

Abstract

The increase in CO_2 emissions represents one of the greatest environmental challenges of our time. Carbon capture technologies are evolving to improve process efficiency and reduce associated energy costs. Among the most promising solutions, the use of nanofluids has proven particularly interesting due to their unique properties in enhancing mass and heat transfer. Nanofluids, consisting of nanoparticles dispersed in a base fluid, offer superior CO_2 absorption potential compared to traditional fluids, thanks to mechanisms such as the shuttle effect, hydrodynamic improvement, and the reduction of gas bubble coalescence.

This study explores the main mechanisms of CO_2 absorption in nanofluids, with a particular focus on the use of metal oxide nanoparticles. The advantages in absorption efficiency and the challenges related to the stability and viscosity of nanofluids are examined. The results show that the application of nanofluids could represent a breakthrough in CO_2 capture, significantly improving the performance of current systems and opening new pathways for greenhouse gas emission mitigation.

Experimental results demonstrate that the addition of metal oxide nanoparticles, such as TiO_2, can significantly improve CO_2 absorption, with performance increases due to the larger surface area available for mass transfer, along with enhanced transport properties, particularly diffusivity. The capture efficiency increases with the nanoparticle mass fraction, but it is necessary to find a balance to avoid the negative effects of agglomeration and increased viscosity.

Keywords: Nanofluids, carbon capture, nanoparticles, innovative solvents

Corresponding author email: chillealice@gmail.com

HYDROGEN PRODUCTION VIA METHANE DECOMPOSITION CHEMICAL LOOPING: HARNESSING CO_2 CAPTURE WITH ADVANCED NI-BASED CATALYSTS

***La Greca E.*[1,2], La Parola V.[1], Fiorenza R.[2], Pantaleo G.[1], Consentino L.[1], Scire S.[2], Liotta L. F.[1]**

[1]*Institute for the Study of Nanostructured Materials (ISMN), National Research Council (CNR), Via Ugo La Malfa 153, 90146 Palermo, Italy*
[2]*Department of Chemical Science, University of Catania, Viale A. Doria 6, Catania, Italy*

Abstract

Methane decomposition chemical looping (CLD) is a highly promising and innovative method for producing high-purity hydrogen (H_2) while minimizing greenhouse gas emissions. This process not only avoids direct emissions of air pollutants or greenhouse gases but also enhances its sustainability by utilizing CO_2 during the oxidation step, which can be sourced from carbon capture. By integrating CO_2 capture and reuse, CLD offers an eco-friendly and efficient solution for hydrogen production. In this context, supported nickel-based catalysts show great potential due to their catalytic activity and stability in reforming processes. The preparation methods of these catalysts are crucial for tailoring their structure, directly impacting their performance in CLD applications. This study focuses on the performance of Ni and Ru-Ni catalysts supported on $LaMnO_3$, synthesized via precipitation assisted by microwave irradiation and sol-gel citrate methods. The redox stability of the catalysts was evaluated through multiple redox cycles during chemical looping experiments conducted isothermally, with alternating gas compositions every 10 minutes from 15 vol% of CH_4 in N_2 (reduction) to 15 vol% of CO_2 in N_2 (oxidation), with CO_2 being potentially recycled in the process. CLD temperatures were selected for each sample based on temperature-programmed reduction tests with methane, choosing the temperature of maximum reduction for each sample. A comprehensive analysis of the structural, morphological, and catalytic properties enabled the study of the impact of synthesis techniques on the performance of these catalysts in hydrogen production via CLD. This research aims to provide valuable insights for developing efficient and sustainable processes to meet the rising demand for clean energy solutions in the modern era.

Keywords: Hydrogen, methane, CO_2 capture, chemical looping

Corresponding author email: eleonoralagreca@cnr.it

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BIO-ELECTROCHEMICAL CONVERSION OF BIOGENIC CO_2 INTO SINGLE CELL PROTEIN

***Pezzuto M.*[1], *Lo Coco R.,*[1] *Frison N.*[1]**

[1]*Department of Biotechnology, University of Verona, Strada Le Grazie 15, 37134 Verona, Italy*

Abstract

Recently, the REPowerEU plan announced the Biomethane Industrial Partnership, which aims to increase biomethane production by 2030 to 35 bcm. In this context, the revamping of anaerobic digester with biogas upgrading facilities represents one of the main strategies to produce more biomethane. At the same time, the availability of biogenic CO_2 will increase, which accounts for 40% of anaerobic digesters' mass balance. A competitive and sustainable technology for the valorisation of the CO_2 derived from biogas upgrading is represented by bio-electrochemical systems (BES) integrated with purple photoautotrophic bacteria (PPB). In particular, the PPB's electroactive capacity permit them to incorporate electrons from a cathode, used for their metabolism to produce high-added value products. The aim of this work is to cultivate PPB in a BES by using CO_2 and recycled nitrogen sourced from anaerobic digestate, under photoautotrophic conditions through their electroactive capacity. Specifically, the CO_2 derived from biogas upgrading is captured and used as a sole carbon source for the PPB growth and to produce single cell protein (SCP). PPB were cultivated in a SBR-BES poised at +200mV with HRT of 10d, equipped with artificial light where Fe(II) is used as an electron donor. The presence of Fe(II) was guaranteed by the electrodeposition of Fe(III)-polynuclear complex (Prussian Blue-PB) in the graphite cathode. Electron uptake experiments with PPB were carried out in a jacketed three-electrode single chamber electrochemical system. Specifically, an electrodeposition of Prussian blue was conducted to investigate the effect on PPB growth and current consumption. Then, a cyclic voltammetry was carried out to characterize the electrochemical activity and the reversibility of the PB modified graphite cathode. The reversibility of the PB represents a key characteristic for using it as a redox mediator for growing photoautotrophically *R. palustris* in order to fix the CO_2. The reversibility was evaluated by measuring the anodic and cathodic peak current ratio which was of 1.07±0.09 for the redox peak potentials centered at 0.42V. A value close to 1 of this ratio indicates that the PB-cathode demonstrates an electrochemical redox reaction that is reversible at the graphite electrode surface. Chronoamperometry on graphite electrodes modified with PB, confirms that PPB are able to accept electrons from an electrode. The average current uptake by *R. palustris* was 2,20±1,2µA/cm^2. Moreover, to reach the long-term stability of the process, the PB-cathode was replaced every three days to avoid the aging of the Prussian Blue coating. In fact, the trend of the current consumed could be and indicator of the aging of the PB-coating. In conclusion, electrodes modified with Prussian blue improved electron transfer and CO_2 uptake to PPB for their photoelectroautotrophic metabolism. The poised PB-biocathode with PB acts as an electron shuttle for biomass growth, due to the reversible redox nature of the PB. This process permit using BES to convert the biogenic CO_2 in the presence of recycled nitrogen from anaerobic digestate into protein-rich microbial biomass (SCP) suitable for aquaculture feeding. The protein content of the produced biomass was of 55% as a dry cell, and a carotenoid content of 1,75g/L. Biogenic CO_2 derived from biogas upgrading can be valorized by purple phototrophic bacteria using BES, as well as generating marketable and valuable products like single cell protein to use as alternative protein in aquaculture.

Keywords: Biological CO_2 conversion, Purple Phototrophic Bacteria, Bio-electrochemical systems.

Corresponding author email: marco.pezzuto@univr.it

CONTINUOUS CARBON CAPTURE AND UTILIZATION IN THE TAYLOR-COUETTE DISC CONTACTOR

***Rudelstorfer G.*[1], *Schwarz A*[1]., *Vogi M.*[1], *Greil R.*[1], *Lux S.*[1]**

[1]*Institute of Chemical Engineering and Environmental Technology, Inffeldgasse 25C. 8010 Graz, Austria*

Abstract

Carbon capture and utilization (CCU) technologies are becoming increasingly vital in the battle against climate change, as they aim to lower greenhouse gas emissions by capturing carbon dioxide (CO_2) from industrial sources and the atmosphere. Captured CO_2 can then be transformed into valuable products, such as chemicals, fuels, and building materials, making CCU a promising approach for enhancing environmental sustainability and driving economic growth.

Process intensification of CCU technologies significantly boost their efficiency. Therefore, the Taylor-Couette Disc Contactor (TCDC), a unique multiphase reactor that utilizes the intense mixing of Taylor-Couette flow, shows a high potential being used in CCU processes. To explore the potential of this technology, two reactive carbon capture systems were studied, using sodium hydroxide (NaOH) and monoethanolamine (MEA) for the reactive chemisorption of CO_2 from flue gas. For the experiments a gas mixture containing 30% CO_2 and 70% N_2 was used in a TCDC column featuring an inner diameter of 50 mm and an active height of 1 meter. The hydraulic performance of both systems was examined, focusing on how gas and liquid flow rates, along with temperature, influenced dispersed gas phase holdup, residence time distribution, and mass transfer. To optimize gas-liquid contact, the rotor disc design was refined. In sodium hydroxide experiments, 0.9 L/min of CO_2 was absorbed in 0.42 L/min 0.1 molar NaOH solution. For the MEA experiments, a 5% MEA solution facilitated the absorption of up to 1.8 L/min of CO_2 with a liquid flow rate of 0.08 L/min. Additionally, the captured CO_2 was utilized through a continuous heterogeneous lithium carbonate precipitation process, integrated into the TCDC. The gaseous CO_2 phase was continuously introduced at the bottom of the column, while an alkaline lithium solution was added at the top. The precipitation of lithium carbonate was induced, with solid particles growing based on the rotational speed. At the column's bottom, these solid lithium carbonate particles agglomerated and could be continuously discharged.

This integrated approach combining carbon capture via chemisorption and the direct utilization of CO_2 through continuous lithium carbonate precipitation in one single column type reactor demonstrates the potential of process intensification for CCU processes, offering a cost-effective and sustainable solution by applying the unique benefits of a flexible gas/liquid Taylor-Couette Disc Contactor design.

Keywords: Taylor-Couette Disc Contactor, carbon capture, multiphase flow, continuous precipitation

Corresponding author email: rudelstorfer@tugraz.at

ECO-FRIENDLY PHOSPHATE-FUNCTIONAL CELLULOSE FOR CO_2 CAPTURE AND CONVERSION

Sehaqui H. [1], ***Hadid M.***[1], ***Kassab Z.***[1], ***El Jaouhari A.***[1], ***Lamnini S.***[1], ***Ghamouss F.***[1], ***Jacquemin J.***[1], ***Ahsaine H.***[2], ***El Kadib A.***[3]

[1]*Materials Science, Energy and Nanoengineering Department, Mohammed VI Polytechnic University (UM6P), Lot 660 – Hay Moulay Rachid, 43150 Benguerir, Morocco*
[2]*Laboratoire de chimie appliquée des matériaux, faculté des sciences, Mohammed V University in Rabat, Morocco*
[3]*Euromed Research Center, Engineering Division, Euro-Med University of Fes (UEMF), Route de Meknes, Rond-point de Bensouda, 30070, Fès, Morocco*

Abstract

Owing to its renewable, abundant, and biodegradable characters, lignocellulosic biomass is considered as an important resource for eco-friendly materials development. Yet, enhancing the properties of lignocellulosics is necessary for their efficient utilization in sectors such as environment, energy, catalysis and beyond. In particular, phosphorylation is a green functionalization route for the introduction of phosphate groups into the structure of cellulose biopolymer conferring it with various properties such as the capacity to adsorb metal ions and to capture CO_2 from the atmosphere. Metal nanoparticles decorating fibrous materials offer an attractive material for catalysis, e.g. for the transformation of CO_2 into sustainable fuel. This presentation exemplify the use of locally abundant resources and green processes to address an issue of great importance in the current era, that is the CO_2 capture and conversion.

Keywords: Cellulose, Phosphorylation, Metal nanoparticles, CO_2 capture, CO_2 conversion.

Corresponding author email: houssine.sehaqui@um6p.ma

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6. Mechanochemistry and mechanical synthesis for green chemistry: chemical reactions and materials state transformations

Oral presentations

SUSTAINABLE AGROCHEMICAL PRODUCTION VIA MECHANOCHEMISTRY

Andrea Casagrande,[1,2] Allan Niidu,[2] Evelina Colacino[1]

[1] Institut Charles Gerhardt (ICGM), University of Montpellier, Montpellier, France
[2] Virumaa College, Tallinn University of Technology, Tallinn, Estonia

The herein presented work aims to illustrate alternative, greener protocols, that can represent an alternative to deliver the synthesis of industry valuable agrochemicals using mechanochemical protocols. The necessity of greener protocols to deliver this reaction stems from the necessity of reduce the environmental impact in targets that have high production volumes, also addressing hazard concerns to the operators, by developing routes that have also simplified setups and less hazardous chemicals.

Various protocols were explored to provide a more sustainable alternative to classical solution-based methodologies as mechanochemistry makes use of transmission of mechanical energy in a solvent-less environment, resulting mainly in less waste production, resource use and energy efficiency, in compliance with green chemistry principles.[1]

Reactions were performed by milling in a vibrating ball mill (VBM) or planetary mill (PBM) for upscale purposes, exploring the effects that different jar and ball material have on the product output. The reactions were performed either completely solventless or with catalytic amounts of solvents, by taking advantage of a technique called liquid assisted grinding (LAG).[2]

Moreover, a greenness assessment was made with the use of toolkits useful to confront green metrics and to assess the adherence to green chemistry principles, that show quantitatively and semi-quantitatively the overall better performance and greenness of the mechanochemical methods against the solution-based commercial routes.[3]

In conclusion, it was shown that greener possibilities to perform alternative solid-state syntheses to already established solution-based protocols are possible, and grace to the simple setup and workup procedures, along with the repurposing of already in-use instruments in the industry (e.g. ball millers), the proposed protocol can be readily implemented in real world industrial scenarios.

Keywords: Mechanochemistry, Ball-milling, Green Chemistry Metrics, Agrochemicals, Solvent-free.

Corresponding author email: evelina.colacino@umontpellie.fr

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SUSTAINABLE PREPARATION OF A WHO ESSENTIAL MEDICINE BY RESONANT ACOUSTIC MIXING

Chatzigiannis C.[1], Colacino E.[1]

[1]ICGM, Univ Montpellier, CNRS, ENSCM, Montpellier, France

Abstract

This study investigates a novel synthetic approach to prepare a World Health Organization essential medicine through Resonant Acoustic Mixing (RAM). Operating at low frequency acoustic energy (60 Hz), RAM facilitates solid-state chemical transformations via intensive mixing. The mechanically activated synthesis is based on mechanochemical rearrangement[1] which involves a cascade reaction sequence. The RAM approach demonstrates advantages over traditional methods by enhancing sustainability and minimizing solvent usage. The process was assessed by green chemistry metrics[2] demonstrating that RAM technology was outperforming compared to the corresponding solution-based methods, representing an environmentally friendly alternative to conventional approaches in organic synthesis and for the preparation of pharmaceuticals in a more sustainable way.

Keywords: Mechanochemistry, Resonant Acoustic Mixing (RAM), Rearrangement, Active Pharmaceutical Ingredients (APIs), Green chemistry metrics.

Corresponding authors email: evelina.colacino@umontpellier.fr

Acknowledgements: IMPACTIVE (Innovative Mechanochemical Processes to synthesize green ACTIVE pharmaceutical ingredients), the research project funded from the European Union's Horizon Europe research and innovation program under grant agreement No. 101057286.

7. Innovative green reactions: synthesis and catalysis

Oral presentations

A SILENT HYDROGEN GENERATOR FOR CONTINUOUS OPERATION ON SUBMARINE AND AUTOMOTIVE APPLICATIONS

***Ines Belhaj*, Bruno Domingues,**
Biljana Šljukić, Marta Martins, Diogo M. F. Santos

Centre of Physics and Engineering of Advanced Materials, Laboratory for Physics of Materials and Emerging Technologies, Chemical Engineering Department, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal

Abstract

This project explores cutting-edge energy storage technologies through the development of a stainless-steel reactor designed for backup power generation in automotive and submarine applications. At the heart of the innovation lies the use of sodium borohydride ($NaBH_4$) as the primary hydrogen storage material. $NaBH_4$ was chosen due to its unique attributes: non-toxicity, high hydrogen content, non-combustibility, stability in alkaline solutions, and ability to generate hydrogen on demand.

Hydrogen production is achieved via catalytic hydrolysis, employing a novel and cost-effective catalyst synthesized by the dynamic hydrogen bubble template (DHBT) technique. This advanced electrodeposition method generates porous, 3D foam-like films with a highly connected pore network, significantly enhancing hydrolysis efficiency. This improvement is critical for ensuring the safe and efficient operation of hydrogen-based backup power generators. The selection of mono-metallic foam materials as catalysts plays a pivotal role in optimizing hydrogen production and storage within the reactor.

This initiative was undertaken as part of a competition sponsored by Instituto Superior Técnico and GALP, challenging teams to devise innovative energy solutions within a constrained budget. The portable hydrogen generator developed represents a leap forward in sustainable energy systems. The project's innovation lies in its creation of cost-effective catalysts for $NaBH_4$ hydrolysis, enabling compact and efficient hydrogen generation suitable for submarines, personal vehicles, and other applications.

This work highlights $NaBH_4$'s transformative potential in energy storage and sets the stage for future advancements in sustainable backup power technologies.

Keywords: sodium borohydride, borohydride hydrolysis, dynamic hydrogen bubble template (DHBT), metallic foams, heterogenous catalysis, submarine and automotive applications, sustainable energy, backup power.

Corresponding author email: ines.belhaj@tecnico.ulisboa.pt

SYNTHESIS OF NEW ARYL-SUBSTITUTED AURONES VIA SUZUKI-MIYAURA REACTION AND BIOACTIVITY ASSESSMENT

***Kakokefalou V.*[1], *Heotis C.*[1], *Katopodi A.*[1], *Tzani A.*[1], *Detsi A.*[1]**

[1]*Laboratory of Organic Chemistry, School of Chemical Engineering, NTUA, Iroon Polytechneiou 9, Zografou 157 80, Athens, Greece*

Abstract

In recent years, Deep Eutectic Solvents (DES) have found a widespread application in a variety of processes, as they are greener and more environmentally friendly than conventional organic solvents. In case the ingredients used for their preparation are of natural origin, the resulting mixtures are called Natural Deep Eutectic Solvents (NADES).
The Suzuki - Miyaura reaction is a metal (usually Pd) catalysed C-C bond formation reaction between a boronic acid or borate ester and an aryl-halide under basic conditions. It is used to produce coupled systems of alkenes, styrenes or di-aryl compounds, which are precursors for the preparation of products with a variety of industrial and pharmaceutical applications.
Aurones are natural products, which belong to the family of minor flavonoids, and possess a wide array of bioactivities. In the present work, the application of the methodology developed in the Laboratory of Organic Chemistry of NTUA for the Suzuki - Miyaura reaction for the synthesis of new aryl-substituted aurones using task-specifically designed NADES as solvents is studied. The new molecules were obtained in high purity and satisfactory yields (41-88%), and the NADES were recycled and reused at least up to 2 times (Figure 1).

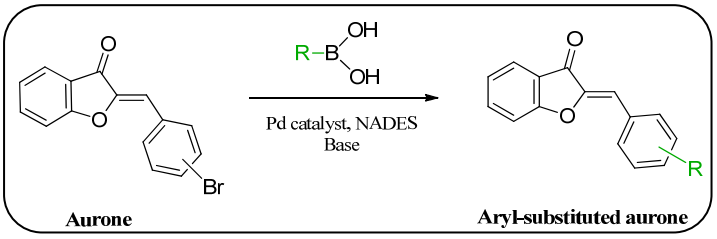

Figure 1. Methodology for the synthesis of the selected molecules.

The new molecules were evaluated for their antioxidant activity through the inhibition of lipid peroxidation of linoleic acid induced by the free radical producer AAPH, as well as for their ability to interact with ctDNA. The majority of the compounds showed satisfactory ability to inhibit lipid peroxidation (35 to 90%), while destabilization of the DNA double helix was achieved (binding energy -10.1 kcal/mol), revealing a possible anti-cancer activity of the new molecules.

Keywords: Aurones, Suzuki – Miyaura Coupling, Bioactivity, NADES, Green Chemistry

Corresponding author email: vasilikikakokefalou@mail.ntua.gr

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ALKALINE EARTH METAL SUPERALKALIS FOR CARBON DIOXIDE AND NITROGEN MOLECULES ACTIVATION: A HYBRID QM-QSPR APPROACH

Wiszowska N.[1], Rogoża N.[1], Sikorska C. [1,2]

[1] *Faculty of Chemistry, University of Gdańsk,*
Fahrenheit Union of Universities in Gdańsk, 80-308 Gdańsk, Poland
[2] *Department of Physics, The University of Auckland*
38 Princes Street, Auckland 1010, New Zealand

Abstract

Superalkalis are clusters of atoms that have low ionization energy. This contribution aims at designing superalkalis for redox applications and as building blocks for cluster-assembled materials. According to our recent results, a superalkali with smaller ionization energy should more easily transfer an electron to counterpart molecules (e.g., CO_2 or N_2) compared to one with a larger ionization energy. We used a hybrid approach that combines *ab initio* computational techniques of quantum chemistry and a machine learning strategy to design and investigate BAe_3 (Ae=Be, Mg, Ca, Sr, Ba) molecular clusters with strong reducing abilities. The studied molecular clusters feature low ionization energies and highly delocalized singly occupied molecular orbital. The BBa_3 has the lowest IE here (3.59 eV), which is smaller than that of any alkali [3.89 eV (cesium atom)]. Moreover, we developed a mathematical model describing the dependence of ionization energy of superalkalis on their composition. The developed quantitative structure-property relationship (QSPR) model predicts the reducing ability of a superalkali, where a suitable alkaline earth metal decreases the ionization energy of the resulting superalkali cluster. Finally, we demonstrated that the BAe_3 electron donors can be used in the reduction of counterpart systems with low electron affinity (such as the carbon dioxide or nitrogen molecules). Our results emphasize how the structure and stability of the BAe_3/**Y** systems (**Y** = CO_2, N_2) can be tuned upon single atom substitution and can be used to bond and remove toxic molecules from the environment.

Keywords: superatom, ionization energy, computational chemistry, reducing agents, QSPR modeling

Corresponding author email: celina.sikorska@ug.edu.pl

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DEVELOPMENT OF NI/CAO-AL_2O_3 CATALYST PELLET FOR HYDROGEN PRODUCTION FROM TREATED BIOGAS VIA SORPTION-ENHANCED STEAM REFORMING REACTION

Nantapong P.[1], Wongsakulphasatch S.[2], Assabumrungratt S.[1], Cheng C. K.[3]

[1] Bio-Circular-Green-Economy Technology & Engineering Center (BCGeTEC), Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330, Thailand
[2] Centre of Excellence on Catalysts and Membrane Technology for Energy and Environment, Department of Chemical Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok 10800, Thailand
[3] Center for Catalysis and Separation (CeCaS), Department of Chemical Engineering, College of Engineering, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates

Abstract

Multifunctional Ni/CaO-Al_2O_3-based catalyst was developed for hydrogen (H_2) production via sorption-enhanced steam reforming (SE-SR) of treated biogas. Parametric effects including reforming temperature (400-900 °C), CO_2 concentration in the treated biogas (0-80 %v/v), steam to carbon molar ratio (S/C=1-4), and type of promoter (Ce vs. Mg) were studied. The influence of parametric effects was firstly determined using Aspen plus V11 software to find suitable operating condition for experiments. The results showed that at atmospheric pressure, reforming temperature of 650 °C, and S/C = 3 is suitable for the production of H_2. The Ni/CaO-Al_2O_3 pellet catalyst was developed for practical application. The effect of preparation method on material performances were tested for H_2 production at CO_2 concentration 40% v/v. The results showed the developed catalyst Ni/CaO-Al_2O_3 provided 81% v/v for 30 mins. The addition of CeO_2 can produce similar amount of H_2 purity with lower S/C = 2. The result is due to the CeO_2 promote dry reforming reaction.

Keywords: Hydrogen production, CO_2 capture, multifunctional material.

Corresponding author email:Suwimol.w@eng.kmutnb.ac.th

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PHYSIOCHEMICAL INSIGHTS INTO ADSORPTION AND THERMAL DEGRADATION OF SHORT- AND LONG-CHAIN PFAS BY REGENERABLE WASTE DERIVED BIOCHAR

Christensen C.S.O. [1]***, Bai L.*** [1]***, Wei Z.*** [1,*]

[1]*Centre for Water Technology & Department of Biological and Chemical Engineering, Aarhus University, Ole Worms Allé 3, 8000 Aarhus C, Denmark*

Abstract

The widespread presence of toxic per- and polyfluoroalkyl substances (PFAS) throughout the water cycle will increase the demand for active treatment of water resources as regulation is implemented in the coming years. Sustainable biochar adsorbents are promising alternatives to granular activated carbon (GAC) for PFAS removal, yet they are challenged by poor short-chain PFAS capture and low regeneration potential. To determine the key biochar property controlling PFAS removal mechanisms, we comprehensively investigated seventeen biochar of varying physiochemical characteristics for their adsorption of two legacy long-chain PFAS and two emerging short-chain PFAS. While batch adsorption tests confirmed the importance of hydrophobic/electrostatic interactions, cation bridging of PFAS anions is also found essential. Likewise, micropore filling played a larger role in the adsorption of short-chain PFAS, which were prone to displacement by long-chain PFAS. Finally, spent wheat straw biochar could be effectively reactivated through 900 °C N_2 thermolysis with complete PFAS degradation, which surprisingly enhanced the adsorption of short-chain PFAS in three cycles due to micropore formation. The findings from this study could aid in the future design and engineering of biochar adsorbents selective towards both short- and long-chain PFAS.

Keywords: Keyword 1, Keyword 2, Keyword: Biochar; PFAS; Adsorption; Water Treatment; Remediation; Reactivation; Thermolysis.

Corresponding author email: zwei@bce.au.dk

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7. Innovative green reactions: synthesis and catalysis

Flash oral presentations

UNVEILING STRUCTURE-ACTIVITY CORRELATIONS IN NI-LA CATALYSTS FOR EFFICIENT CO_2 METHANATION

***Consentino L.*[1,2], *González-Castaño M.*[3], *Bobadilla L.F.*[3], *Gruttadauria M.*[2], *Liotta L.F.*[1], *Odriozola J.A.*[3]**

[1] *ISMN-CNR, Via U. La Malfa 153, 900146 Palermo, Italy*
[2] *STEBICEF Department Ed. 17, University of Palermo, Viale delle Scienze, 90128 Palermo, Italy*
[3] *Department of Inorganic Chemistry, University of Seville (ICMS-CSIC), C/Americo Vespucio 49, 41092 Seville, Spain*

Abstract

In response to global initiatives for carbon neutrality, particularly the European Union's goal of achieving carbon neutrality by 2050, CO_2 methanation presents a promising route for synthesizing synthetic natural gas (SNG) within the power-to-gas (PtG) framework. This process, based on the Sabatier reaction ($CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$), offers a sustainable method for converting carbon dioxide, a greenhouse gas, into valuable hydrocarbon fuels. However, despite its thermodynamic favourability, the CO_2 methanation reaction is kinetically limited and requires efficient catalysts to enhance conversion rates. This study explores the structure-activity relationship of Ni-supported systems and perovskite-based catalysts for improving catalytic activity and durability in CO_2 methanation. Ni metal is highlighted for its cost-effectiveness and wide availability, making it a key active phase in these reactions. The role of oxygen vacancies, critical for CO_2 adsorption and methane production, is emphasized, particularly within perovskite structures that exhibit excellent oxygen mobility and resistance to coking. Ni-La perovskites demonstrate remarkable stability and performance, influenced by synthesis methods that optimize the Ni phase distribution and enhance catalytic properties. The research compares lanthanum nickelate prepared via one-pot synthesis with Ni-impregnated lanthanum oxide, investigating how these structures influence catalytic efficiency. Microwave radiation-assisted synthesis techniques was used to improve Ni dispersion and phase homogeneity. This study establishes meaningful correlations between catalyst structure and function, focusing on surface species generation and CO_2 methanation rates. Additionally, it highlights the critical role of partial or complete catalyst reduction in enhancing reaction performance. These findings contribute valuable insights into the design of advanced catalysts for CO_2 conversion processes, supporting environmental sustainability and promoting the transition to post-fossil fuel energy solutions.

Keywords: CO_2 methanation, catalyst structure, Ni-La perovskite, in situ DRIFTS-MS

Corresponding author email: lucaconsentino@cnr.it

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ENZYME-FUNCTIONALIZED BIOCHAR FOR THE ENHANCED TREATMENT OF WATER CONTAMINATED WITH DICLOFENAC AND AMOXICILLIN

***Peleja A.*[1], *Rocha H.*[1], *Calisto V .*[1], *Almeida Â.* [1]**

[1]*Department of Chemistry and CESAM, University of Aveiro, 3810-193, Aveiro, Portugal*

Abstract

The occurrence of pharmaceuticals in the aquatic environment is a result of the ineffectiveness of conventional wastewater treatment methods, leading to their accumulation in the ecosystems. The use of porous carbonaceous materials has been identified as a potential strategy for the advanced treatment of effluents. However, the application of these adsorbents has disadvantages, such as the difficulty of reusing them after saturation. In contrast, enzymatic degradation is an environmentally friendly approach. Oxidoreductases, such as laccase and peroxidase, have been shown to play an important role in the biotransformation of phenolic and non-phenolic compounds, and have been applied to the removal of contaminants from water, such as pharmaceuticals and pesticides. The use of enzymes presents some challenges, mainly in terms of their loss of activity/denaturation associated with the conditions of the medium. This issue can be overcome by immobilizing them on a support, providing "protection" against external changes while maintaining their integrity. Hence, this work aims to produce a modified biochar through the enzymatic immobilization of laccase (Lac, from fungi) or peroxidase (HRP, from horseradish). The biochar was produced by microwave pyrolysis of spent brewery grains (solid residue from the brewery industry). The modified biochar was applied to remove pharmaceuticals from water through the possible synergy between the processes of adsorption and enzymatic degradation. For this purpose, diclofenac (DCF, a non-steroidal anti-inflammatory) and amoxicillin (AMX, an antibiotic) degradation tests were carried out, firstly, by dissolving each enzyme and substrate (0.1 mM hydrogen peroxide, only for HRP) at a known concentration of 0.1 and 0.01 mg/mL in a 5 mg/L pharmaceutical solution, at pH 5 and pH 7 for Lac and HRP, respectively, at a controlled temperature (40 ºC and 25 ºC), for 24 h at 350 rpm. Later, the adsorption/degradation performance of the waste-based biochar (500 mg/L), functionalized with commercial Lac and HRP, towards DCF and AMX, was evaluated, in batch systems, at varying contact times, under the same conditions as the tests described above for the free enzyme. After incubation, the samples were filtered and analyzed through High Performance Liquid Chromatography (HPLC) or Micellar Electrokinetic Chromatography (MEKC). Overall, in free form, Lac proved to be efficient in the biotransformation of DCF, while HRP degraded AMX in aqueous matrices. In addition, the biochar-enzyme composite has the potential to remove the tested pharmaceuticals through adsorption combined with enzymatic degradation when compared to non-functionalized biochar. These results show that enzymatic modification of adsorbents is a good strategy to promote their regeneration/reuse in wastewater treatment, focusing resource on circularity.

Keywords: green catalysts, biotransformation, wastewater treatment, adsorption, waste-based biochar

Corresponding author email: catarina.malpique@ua.pt

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7. Innovative green reactions: synthesis and catalysis

Posters

SYNTHESIS AND CHARACTERIZATION OF WO_3/TiO_2 NANOCOMPOSITES DECORATED WITH Ag NPs FOR PHOTOREDUCTION OF HIGHLY TOXIC Cr (VI) AND ANTICANCER POTENTIAL

Aldirham S. H. [1], ***Hadi M.***[1], ***Helal A.***[2], ***Elbehairi S. E. I.*** [3], ***Shawaf J.***[1], ***Alqhtani N.***[1], ***Alkhaloofa F.***[1], ***Aljaloud K. B.***[1], ***Shkir M.*** [1], ***Ali A. M.***[1]

[1]*Department of Physics, Faculty of Science, King Khalid University, P.O.Box. 9004, Abha, Saudi Arabia*
[2] *Nanostructured Materials and Nanotechnology Department, Advanced Materials Institute, Central Metallurgical R&D Institute (CMRDI), P.O. Box 87 Helwan, Cairo 11421, Egypt.*
[3]*Department of biology, Faculty of Science, King Khalid University, Abha, Saudi Arabia*

Abstract

In the recent past, there has been a huge demand for multifunctional materials that can be used in dual applications. Hence, herein the Ag-doped 5%WO_3/TiO_2 nanocomposite with various contents of Ag nanoparticles (NPs) was prepared using the sol-gel method for photocatalyst and biomedical applications. X-ray diffraction (XRD), FT-Raman, SEM, TEM, EDX, DRS-UV/Vis, PL spectroscopic, BET surface area analysis, LCR meter, and the sulphorhodamine B (SRB) assay were used to characterize the prepared samples. XRD results showed that the crystallite size slightly increased with increasing the Ag NPs content. EDX analysis confirmed the presence of Ti, O, W, and Ag in the prepared nanocomposites. According to Tauce's plot, the band gap decreased from 3.00 to 2.59 eV owing to the formation of localized states during the colligation of tungsten oxide and titania corresponding well with particle size values obtained from XRD and SEM. The photocatalytic activity revealed that the 4%Ag@WO_3/TiO_2 NP was able to do the photoreduction of the high toxicity of Cr(VI) to nontoxic Cr(III). This enhancement is attributed to the surface plasmon resonance (SPR) and the inhibition of charge carrier recombination[1,2], as confirmed by PL results. The anticancer efficiency of Ag@%WO_3/TiO_2 was studied using three human cancer cell lines: human breast carcinoma (MCF-7), human prostatic adenocarcinoma (PC-3), and human colorectal adenocarcinoma (HT-29). The present work showed that Ag@WO_3/TiO_2 NPs were successfully prepared and controlled the growth of all types of cancer cells. These outcomes indicate that the prepared nanocomposite will be highly useful in multifunctional devices.

Keywords: Ag@%WO_3/TiO_2 nanocomposite, XRD, optical properties, anticancer activities, photoreduction.

Corresponding author email: saldrhm@kku.edu.sa

TAILORING THE STRUCTURAL, MORPHOLOGICAL, OPTICAL PHOTOLUMINESCENCE, DIELECTRIC, AND ELECTRICAL PROPERTIES OF NiO NPs: AN EFFECT OF SDS CONCENTRATIONS

Aljaloud K., ***Aldirham S. H., Shawaf J., Alkhaloofa F., Alqhtani N., Shkir M., Ali A. M., AlFaify S.***

Department of Physics, College of Science, King Khalid University, Abha 61413, Saudi Arabia.

Abstract

Metal oxide nanoparticles are of great importance for several applications in transparent conducting oxides, optoelectronics, solar cells, supercapacitors, etc., among several metal oxides, nickel oxide (NiO) has been found to have fascinating multifunctional properties and applications. Hence, in this work, Nickel oxide (NiO) nanoparticles (NPs) were synthesized using a sol-gel chemical route with different concentrations of sodium dodecyl sulfate (SDS) ranging from 0 to 5 grams. The synthesized NPs were characterized using several techniques, including X-ray diffractometer (XRD), Fourier-transform Raman (FT-Raman) spectroscopy, scanning electron microscopy/energy dispersive X-ray spectroscopy (SEM/EDS), diffused reflectance spectroscopy (DRS) impedance spectroscopy to investigate their structural, vibrational, morphological/compositional, optical properties, electrical and dielectric properties, respectively. XRD study showed that the NiO NPs exhibited good crystallinity, with crystallite size decreasing from 15 nm for pure NiO to 4 nm for 5 g SDS-NiO, as SDS concentration increased. The estimated optical band gaps were found to be enhanced from 3.55 eV for pure NiO to 3.77 eV for the 5 g-SDS NiO sample. The dielectric constant and electrical conductivity have been systematically enhanced with increasing content of SDS in the synthesis of NiO NPs. These outcomes show that the structural, vibrational, compositional/morphological, optical, dielectric, and electrical properties of NiO are significantly enhanced by reducing the particle size with the concentration of SDS in NiO. Hence, these NPs may be useful in multifunctional devices.

Keywords: NiO nanosynthesis, Structural properties, Optical properties, Photoluminescence, Dielectric properties.

Corresponding author email: kaltham_88@hotmail.com

A LOW-COST-G-C_3N_4@PbI_2 NCs SYNTHESIS, STRUCTURAL, VIBRATIONAL, OPTICAL, PHOTOLUMINESCENCE, AND ELECTRICAL STUDIES: A NOVEL MATERIAL FOR OPTOELECTRONIC DEVICES

***Alkhaloofa F.*, Shawaf J., Aldirham S. H., Alqhtani N., Aljaloud K., Ali A. M., AlFaify S., Shkir M.**

Department of Physics, College of Science, King Khalid University, Abha 61413, Saudi Arabia.

Abstract

In the current scenario, graphitic carbon nitride (g-C_3N_4)- based nanocomposites (NCs) are in great demand owing to their versatile applications in a wide range of devices, such as gas/radiation detection, photodetection, environmental, fuel cell, etc. . In view of the above-mentioned applications, the authors aim to prepare PbI_2-decorated g-C_3N_4 NCs to improve their key characteristics. Hence, we have synthesized the PbI_2 decorated g-C_3N_4 NCs by coprecipitation route and studied their photo-physical properties. In this work, we report a cost-effective synthesis of PbI_2@g-C_3N_4 NCs with 0, 0.10, 0.25, 0.50, 0.75, and 1.00g of g-C_3N_4 concentrations. X-ray diffraction and FT-Raman studies confirm the synthesis of PbI_2@g-C_3N_4 NCs. The intensity of XRD peaks and calculated size of crystallites (59-75 nm) reveal the good crystalline nature of the NCs. Raman spectral studies reveal that in PbI_2@g-C_3N_4 NCs, the lifetime of the LO phonon is reduced through the bottleneck effect. Subsequently, there is a rise in the phonon energy as the g-C_3N_4 concentration increases, suggesting a significant increase in electron-phonon coupling and higher crystal quality, which means there is a corresponding increase in non-radiative losses. The vibrational study reveals that the PbI_2 decorated g-C_3N_4 nanosheets are much more significant for hot carrier solar cell devices. EDX/SEM e-mapping analyses confirm the uniform distribution of C, N, Pb, and I throughout the specimens. The hexagonal nanocrystals/nanoplates and PbI_2 decorated g-C_3N_4 nanosheet-like morphologies were detected in SEM and HR-TEM images for pure and g-C_3N_4@PbI_2 NCs. A diffused reflectance study was performed, and the optical band gap of NCs was obtained from K-M-Tauc's plots and found to be in the range of 2.35-2.38 eV. Furthermore, the photoluminescence (PL) emission spectra were recorded at 360 nm excitation wavelength, and the two emission peaks were observed at 440 nm (blue) and 530 nm (green), these emission peaks suggest that the prepared nanostructures can be used to develop blue and green LEDs. The I-V electrical properties of NCs were studied under dark and illumination conditions. The observed results show that the prepared g-C_3N_4@PbI_2 NCs are good contenders for optoelectronic applications.

Keywords: PbI_2@g-C_3N_4 nanocomposites, SDS assisted chemical synthesis, structural properties, vibrational analysis, morphology and compositional study, optical properties

Corresponding author email: 444817120@kku.edu.sa

DEVELOPMENT OF g-C_3N_4@CeO_2 NANOSTRUCTURES FOR MULTIFUNCTIONAL APPLICATIONS

Alqhtani N., Hadi M., Alkhaloofa F., Aldirham S., Shawaf J., Aljaloud K., Shkir M., Ali A. M.

Department of Physics, College of Science, Faculty of Science, King Khalid University, Abha, 61413, P.O. Box 9004, Saudi Arabia

Abstract

Graphite carbon nitrite loaded cerium oxide (g-C_3N_4/CeO_2) composite is a semiconductor material that has received much attention in the field of research due to its great importance in solving environmental and water problems closely related to our daily lives. So, in this work, a low-cost route is employed to synthesize the g-C_3N_4/CeO_2 and characterize using state-of-the-art experimental techniques. X-ray diffraction (XRD) and Raman scattering (RS) and are used to examine the sample's structural attributes. Diffuse reflectance spectroscopy (DRS) is used to investigate the optical properties, and the band gap evaluation was done. The elemental composition of the synthesized composite was performed using EDX analysis, and the morphology was investigated using scanning electron microscopy (SEM) as well as transmission electron microscopy (TEM). As a result of working on the optical properties, we found that by increasing the concentration of the graphite carbon nitrite doping cerium oxide composite, the bandgap energy decreases, and the recombination rate is inhibited. In future work, the g-C_3N_4/CeO_2 composites will be developed with different concentrations to make them suitable for several applications, such as environmental and anti-cancer treatments.

Keywords: doping cerium oxide, characterizations, structural attributes, optical properties, morphological characteristics, concentrations, and recombination.

Corresponding author email: dr_nor12moh@hotmail.com

EFFECTS OF REDUCTION CONDITIONS DURING SUPERCRITICAL DEPOSITION ON PROPERTIES OF Pt/C ELECTROCATALYSTS FOR PEM FUEL CELLS

Alsuhile. A. [1]***, Erkey C.*** [1,2]

[1] *Department of Chemical and Biological Engineering, Koç University, Rumeli Feneri Yolu,34450 Sarıyer, Istanbul, Turkey*

[2] *Koç University Hydrogen Technologies Center, Rumeli Feneri Yolu, 34450 Sarıyer, Istanbul, Turkey*

Abstract

Green technologies play a crucial role in achieving sustainable energy systems. Among these, green hydrogen has emerged as a promising energy carrier due to its remarkable gravimetric energy density (142 MJ/kg, upper heating value) and zero carbon dioxide emissions. Polymer electrolyte membrane (PEM) fuel cells utilize green hydrogen to generate electricity through an electrochemical reaction with oxygen, offering a promising pathway for clean energy. However, PEM fuel cells are currently considered an expensive technology, primarily due to the high cost of Pt-based electrocatalysts. Developing innovative Pt-based electrocatalysts through sustainable synthesis methods is essential to overcome cost barriers and to make PEM fuel cell technology more widespread. Supercritical deposition (SCD) is a green synthesis method that provides precise control over Pt loading, nanoparticle size, and dispersion, making it highly suitable for preparation of Pt/C electrocatalysts. In SCD, a platinum precursor such as Pt(cod)(CH3)2, is adsorbed onto the surface of the carbon support in the presence of scCO2. Subsequently, the adsorbed Pt precursor is reduced to Pt nanoparticles using a wide variety of techniques. In this study, two reduction routes —chemical in-situ and ex-situ reduction—were investigated for depositing Pt onto a commercial support, carbon black (Vulcan-XC-72). In the in-situ route, the Pt precursor was reduced in a supercritical CO_2 (SC-CO_2) and H_2 mixture (1.5 mol% H2) at 27.6 MPa and 80°C. For the ex-situ route, the Pt precursor was reduced under pure H_2 flow at 80°C. Both routes yielded electrocatalysts with approximately 26 wt% Pt loading. The average sizes of the Pt nanoparticles were determined as 4.1 nm and 4.7 nm, respectively, as calculated from XRD data and confirmed by STEM analysis. XPS analysis revealed a significant improvement in the atomic percentage of metallic Pt^0, reaching 85% in both synthesized electrocatalysts compared to 70% in the commercial Pt-C (30 wt%) electrocatalyst. This enhancement indicated that the chemical reduction routes contribute to a higher metallic Pt^0 content, which is critical for optimizing oxygen reduction reaction (ORR) activity. The ORR activity and stability of the synthesized electrocatalysts were measured and compared to the commercial Pt-C 30 wt% electrocatalyst.

Keywords: Supercritical deposition (SCD), Oxygen reduction reaction (ORR), PEM fuel cell, Electrocatalyst

Corresponding author email:cerkey@ku.edu.tr

DESIGN OF TITANIUM DIOXIDE NANOMATERIALS AND THEIR USE AS PHOTOCATALYSTS FOR SUSTAINABLE APPLICATIONS

***Calabrese C.*[1], *Maertens A.*[2], *Piras A.*[2], *Marcì G.*[3], *Garcìa E. I.*[4], *Aprile C.*[2], *Liotta L. F.*[1]**

[1]*Institute for the Study of Nanostructured Materials (ISMN)-CNR, via Ugo La Malfa, 153, 90146 Palermo, Italy*
[2] *Unit of Nanomaterials Chemistry, Department of Chemistry, University of Namur, NISM, Rue de Bruxelles, 61-5000 Namur, Belgium*
[3] *University of Palermo, Department of Engineering, Viale delle Scienze Ed. 6, 90128 Palermo, Italy*
[4] *University of Palermo, STEBICEF, Viale delle Scienze Ed. 16, 90128 Palermo, Italy*

Abstract

The design of nanomaterials for environmental remediation is an ongoing challenge aimed at promoting a more sustainable and circular economy. In this context, the development of heterogeneous photocatalysts has been considered one of the strategies to face these issues.

Herein, a novel sol-gel synthesis was investigated and developed as a suitable method to prepare TiO_2 nanomaterials with photocatalytic activity. The synthetic method has been designed by changing some reaction parameters, such as the type of solvent, the addition of the swelling agent, the stirring speed, and the calcination conditions. The textural properties of the obtained materials were analysed by N_2 physisorption measurements, whereas the morphology of the solids was investigated via transmission electron microscopy. X-ray diffraction analysis was carried out on both dried powders and calcined materials to examine their crystalline structure. It was found that the different phase compositions of the materials are related to the specific synthesis medium. The use of ethanol, as the reaction solvent, allowed anatase TiO_2 nanomaterials with a higher specific surface area, pore volume, and crystallinity than the analogous solids prepared in water instead of ethanol. An inhomogeneous morphology, which evolved into a rutile phase, was observed when TiO_2 powders were synthesized in water without using ethanol. Selected TiO_2 samples were tested as heterogeneous catalysts choosing the photodegradation of Rhodamine B, under UV-A light irradiation, as a target reaction. The potential versatility of TiO_2 nanopowders was also investigated in the H_2 production by UV-assisted photoreforming of hydroalcoholic solutions. In all the catalytic tests, the anatase phase materials, prepared in ethanol, showed better photocatalytic performance than those prepared in water.

Keywords: TiO_2, porous nanoparticles, sol-gel synthesis, photocatalysis, photoreforming.

Corresponding author email: carla.calabrese@cnr.it

MODIFICATION OF COCOA BEAN SHELL WITH HIGH VOLTAGE ELECTRICAL DISCHARGE

Barišić V., Čorković I., Flanjak I., Jozinović A., Babić J., Lončarić A., Šubarić D., Ačkar Đ.

Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia

Abstract

The chocolate industry generates huge amounts of waste which represents an environmental problem because of pollution. Cocoa bean shell is one of the wastes generated during cocoa processing which is rich in fibers and bioactive components. Researchers have been trying in the last few years to find cocoa shell applications in different industries. Some of the most important uses of cocoa shell are as an adsorbent, in the production of biofuels, as a feedstuff, in food production, etc. This research aimed to determine the degree of modification of cocoa shell with high voltage electrical discharge (HVED). HVED is a nonthermal method that is used for the extraction of bioactive components, disinfection, modification, etc. In this research, cocoa shell was milled and HVED treated at a concentration of 10%. Treatments were carried out during 5 minutes at 20, 40, 60, and 80 Hz. Also, the treatments were carried out with the flow of air through the discharge needle. After the treatments samples were centrifuged, dried at 50 °C, and milled through the sieve of 1 mm. Methods that were used to determine the degree of modification were oil binding capacity (OBC) and Fourier Transform Infrared Spectroscopy (FTIR). Oil binding capacity increased for all treated samples compared to untreated cocoa shell while the highest OBC was in the sample that was treated at 60 Hz. FTIR analysis showed some shifts of the bands after the treatment which shows that there are reactions of cocoa lignocellulosic material with species formed during HVED treatment.

Keywords: cocoa bean shell, HVED, fibers, FTIR

Corresponding author email: dackar@ptfos.hr

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Zn-Al/Cr/Fe MIXED OXIDES AS PHOTOCATALYSTS FOR DYE REMOVAL

***Hadnađev-Kostić M.*[1], *Vulić T.*[1], *Karanović Đ.*[1]**

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia*

Abstract

Environmental pollution and its negative influence on human health and eco-systems represent a significant challenge nowadays. Considering that new, persistent and toxic pollutants are constantly emerging, there is an ongoing quest for eco-friendly materials that could be used for environmental remediation. Azo dyes, such as brilliant cresyl blue (BCB) and methylene blue (MB), highly contribute to the global increase of water pollution due to their extensive use in the modern chemical industry. Compared to other purification processes, photocatalysis has emerged as eco-friendly, straightforward and simple approach to wastewater treatment. Mixed oxides, derived from layered double hydroxides, have been recently used as promising photocatalytic materials for water treatment. ZnAl, ZnCr and ZnFe layered double hydroxides were synthesized by low supersaturation coprecipitation method with the Zn^{2+} molar ratio of 0.7 and M^{3+} (Al^{3+}, Cr^{3+} or Fe^{3+}) molar ratio of 0.3. The precipitates were dried (100°C, 12h) and thermally treated/activated at 500°C in order to obtain mixed oxides. An in-depth analysis of structural (XRD and FTIR analysis) and textural (low temperature nitrogen adsorption) properties of obtained materials was conducted. The results indicated that the variation of trivalent ion significantly influenced the mixed oxide phase composition and structure, as well as their textural properties. Photocatalytic degradation of test pollutants (BCB and MB) revealed exceptional efficiency of ZnAl mixed oxide for complete decolourization of both solutions after 5h, whereas ZnCr 500 degraded 45% of MB dye and 82% of BCB dye, while ZnFe 500 successfully degraded 77% of MB dye and 62% of BCB dye. The difference in photocatalytic behaviour among studied ZnAl, ZnCr and ZnFe mixed oxides could be explained with the difference in the formation of photocatalytic active phases, especially ZnO and Zn-mixed oxide phases, during thermal activation. Besides that, during thermal treatment smaller mesopores and larger surface area, desirable for photocatalytic application, were formed when Al was used as trivalent constituent cation. The results indicate that careful selection of photocatalyst composition and thermal treatment enable the development of novel, enhanced and efficient photocatalytic materials that would contribute to greener future.

Keywords: photocatalytic degradation, azo-dyes, semiconductors, wastewater treatment

Corresponding author email: hadnadjev@uns.ac.rs

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ENERGY-EFFICIENT SYNTHESIS OF MAGNETIC MATERIALS BY PROCESSING IRON-CONTAINING LIQUID WASTE

Kochetov G.*, *Samchenko D.

Kyiv National University of Construction and Architecture,
Povitryanikh Sil ave., 31, 03037 Kyiv, Ukraine

Abstract

The traditional technologies for production of magnetic materials consume substantial amount of energy and resources. The hydrophase ferritization is a promising cost-efficient methods of synthesis, as it allows to obtain magnetic materials by processing of iron-containing liquid waste. Industrial enterprises generate substantial amount of toxic exhausted high-concentration etching solutions. Energy-efficient magnetic fields activation was used to initiate the ferritization processing of those high-concentration solutions at ambient temperatures instead of thermal one. It enables a cost-efficient consumption of energy and water at an industrial plant.

The aim of the study is based on the results of qualitative and quantitative composition of the ferritization sediments and grain size of their iron-containing particles, to explore the possibilities of further utilization of the sediments. Variable study parameters of ferritization process were: initial pH values of the solutions, initial concentrations of total iron ions and duration of the aeration treatment of the reaction mixture. The XRD indicated that the formed sediments contained phases of ɣ-FeOOH, δ-FeOOH, Fe3O4, and ɣ-Fe2O3. Granulometry analysis showed that these sediments were highly dispersed and heterogeneous. Chemically stable phase of magnetite was obtained in the composition of sediments with initial concentration of iron ions in the reaction mixture of 16.6 g/dm^3, pH value of 11.5 and the process duration of 15 min. The study results demonstrated feasibility of further possible use of such materials with a high magnetite content for production of environmentally friendly ferromagnetic sorbents. The sediment powder was tested for sorbtion of zinc ions. In addition, a tuff-based sorbent modified with sediment powder was obtained. A high degree of removal of zinc ions from wastewater (up to 99.8%) using the obtained materials was achieved. The resulting sorbents are easily separated from the liquid phase on magnetic filters. Besides that, introduction of 15% by mass. either of wastewater treatment sediments or the spent sorbents in the composition of protective powder paints do not impair the main mechanical properties of the coatings. Moreover, obtained coatings increase shielding of electromagnetic radiation in the megahertz range by 4 times compared to standard ones.

Application of exhausted etching solutions as a production input allows to obtain marketable products from industrial waste and at the same time can help to prevent environmental pollution.

Keywords: Keywords: energy-efficient synthesis, magnetic materials, sorbents, ferritization

Corresponding author email: gkochetov@gmail.com

GLYCEROL AS A GREEN SOLVENT FOR COPPER(I)-CATALYZED 1,3-DIPOLAR CYCLOADDITION: SYNTHESIS OF NOVEL 1,2,3-TRIAZOLE FRAMEWORKS BASED ON OUINOLINONE, QUINAZOLINONE AND COUMARIN CORE

Komar M.[1], García-Álvarez J.[2], Jakovljević Kovač M.[1], Molnar M.[1]

[1]Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek
[2]Laboratorio de Química Sintética Sostenible (QuimSinSos), Departamento de Química Orgánica e Inorgánica, Instituto Universitario de Química Organometálica "Enrique Moles" (IUQOEM), Facultad de Química, Universidad de Oviedo, E-33071 Oviedo, Spain

Abstract

Developing an environmentally friendly reaction medium in organic synthesis has gained significant attention in recent years. Glycerol, a byproduct of biodiesel production, has emerged as a versatile and benign solvent in the synthesis of heterocycles. Its unique chemical and physical properties, including being non-toxic, biodegradable, and polar, make it an acceptable alternative to traditional organic solvents. The most well-known reaction of click chemistry is the copper(I)-catalyzed alkyne-azide cycloaddition (CuAAC) which represents 1,3-diploar cycloaddition of terminal alkyne and an azide to form 1,2,3-triazole. CuAAC is highly regioselective due to the copper(I) catalyst, which directs the reaction to form the 1,4-disubstituted triazole with high selectivity.

In this study, we explore glycerol as a green alternative for conducting the copper(I)-catalyzed 1,3-dipolar cycloaddition of alkynes and azides based on quinolinone, quinazolinone, and coumarin cores. This approach facilitates the efficient synthesis of 15 novel 1,2,3-triazole frameworks and highlights the synergistic effect of glycerol and copper(I) iodide as a catalyst in click chemistry, offering an eco-friendly and efficient route to access a diverse library of bioactive heterocycles with potential pharmacological properties.

Keywords: 1,3-dipolar cycloaddition, 1,2,3-triazole, glycerol, copper(I) iodide, heterocycles

Corresponding author email: mmolnar@ptfos.hr

IMPACT OF CA CONCENTRATIONS ON THE SYNTHESIS AND PHYSICAL PROPERTIES OF $ZNFE_2O_4$ MAGNETIC NANOPARTICLES

Sdran N.A., Shkir M., Ali H.E.

Department of Physics, College of Science, King Khalid University, P.O. Box 9004, Abha, Saudi Arabia.

Abstract

In the recent past, ferrites are highly applicable in various applications such as switches used in refrigerators for heat sensing, ACs (air conditioners), electronic ovens, MRI/hyperthermia, optoelectronics, etc. Hence, herein we have facilely synthesized the $ZnFe_2O_4$ nanoparticles (ZF NPs) in the presence of citric acid (CA) as fuel/medium at different temperatures as well as at a constant optimized temperature with varying CA concentrations. The properties of the obtained ZF NPs like phase purity, particle size, surface area, and agglomeration are primarily influenced by the heat generated during synthesis. The obtained NPs were characterized using various techniques to investigate the impact of CA concentrations on the physical properties of ZF NPs. Hence, it was noticed that all the XRD parameters depend on CA fuel concentrations. The calculated crystallite size decreases from 25 to 15 nm, and the surface area increases from 42 to 72 m^2/g as fuel concentrations increase from 0.25 to 5.0 g. FT-Raman Spectroscopy gave good matching of vibrational modes in the final product with the previous studies. Scanning electron microscopy shows that the average grain size decreased from 36 to 23 nm with increasing CA concentrations. EDX/SEM e-mapping analysis confirms the synthesis of ZF NPs with good homogeneity. Optical band gap energy showed an increase with increasing CA concentrations, from 2.05 to 2.32 eV as fuel concentrations increase from 0.25 to 5.0 g. Furthermore, we have studied the dielectric and electrical properties of the synthesized ZF NPs which will be discussed. Results indicate that the fuel concentrations is playing a key role in inhibiting the growth of nanoparticles which keeps them of low dimension and enhance the other physical properties.

Keywords: ZF NPs; combustion synthesis; structural properties; optical properties; dielectric and electrical properties.

Corresponding e-mail: njod.m7@gmail.com

SYNTHESIS OF METAL TUNGSTATE FOR ENVVIRONMENTAL REMEDIATION APPLICATIONS

***Shawaf J.*, Hadi M., Alkhaloofa F., Aldirham S., Alqhtani N., Aljaloud K., Shkir M., Ali A. M.**

Department of Physics, College of Science, Faculty of Science, King Khalid University, Abha, 61413, P.O. Box 9004, Saudi Arabia

Abstract

Metal tungstate has gained significant interest due to its distinctive structural, optical, photoluminescent, magnetic, and photocatalytic features, chemical stability, tunable band structures, and resilience. Among several metal tungstate, barium tungstate is found to be one of the best materials from an application point of view. Hence, in the present work, a series of barium tungstate/graphitic carbon nitride ($BaWO_4$/g-C_3N_4) nanocomposites were prepared using different amounts of g-C_3N_4 (0.1, 0.25, 0.5. 0.75, and 1 gm) using a low-cost co-precipitation technique. The structural properties of the synthesized nanoscale $BaWO_4$/g-C_3N_4 nanocomposites were investigated by using X-ray diffraction and FT-Raman spectroscopy techniques. The elemental composition of these nanoscale materials was analyzed through Energy-dispersive X-ray spectroscopy/scanning electron microscope elemental mapping and X-ray photoelectron spectroscopy analysis. The morphology was examined by using field emission scanning electron microscopy and transmission electron microscopy. The optical properties were assessed by diffused reflectance spectroscopy. Furthermore, the impact of g-C_3N_4 concentrations on photocatalytic and bioactivities of $BaWO_4$ was studied. The outcomes reveal that the prepared $BaWO_4$/g-C_3N_4 nanocomposites are highly applicable for biomedical and environmental remediation applications.

Keywords: $BaWO_4$/g-C_3N_4 nanocomposites, structural properties, morphological/compositional study, optical properties antimicrobial and photocatalysis

Corresponding author email: shawaf1982@hotmail.com

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CONTACT

Mladen Radišić,
CEO
mladen@foodscalehub.com

foodscalehub.com

info@foodscalehub.com
Trg Dositeja Obradovića 8
21000 Novi Sad,
SERBIA

instagram.com/foodscalehub/
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