1st Conference for Green Engineering, Sustainable Materials and Technologies for Circular Economy

GREEN CIRC 2024

Faculty of Technology and Metallurgy,
University Ss. Cyril and Methodius in Skopje
22–23 April, 2024

Skopje, 2024

1st Conference for Green Engineering, Sustainable Materials and Technologies for Circular Economy

CIRC 2024

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University Ss. Cyril and Methodius in Skopje,
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First conference on green engineering, sustainable materials and technologies for circular economy

22 April 2024	23 April 2024
9,00 - 9,30 h - Registration	9,30 -10,00 h - Registration
9,00-9,30 h - Poster setting up	10,00-10,150h - Hackathon opening
9,30 - 10,00h - Welcome and Opening Remarks	10,15-11,00h - Company presentations: Company 1- REPLEK Pharm, Company2 - M-Fashion, Company 3-ZAVAR, Company 4 - TITAN USJE, Company 5 - PAKOMAK, Company 6 - BIONIKA, Company 7-SANDA.
10,00-10,20h - Trajan Angelovski (President of Industrial chamber at the Economic Chamber) Support of green and digital transformation and academia role	11,00-11,15h -FTM_UCIM Presentation FITR project Green and sustainable recycling of rubber / Marija Prosheva
10,20-10,40h - Teodora Obradovik (Ministry of Environment and Physical Planning Green Agenda and the challenges for Macedonia	11,15-13,00h - HACKATHON Presentations of students idea (5 min present + 5 min answers)
10,40-11,00h -Anita Koteska - Together4circular Green women leadership	
11,00-11,45h - Prof. Jamie Grunlan, Leland T.Jordan"29 Green and sustainable Nanocomposites for Food and Fire Protection	13,00-13,30h - Coffee break
11,45-12,30h - Coffee break	13,30 - 14,00h - Winner Awarding
12,30-13,30h - Opening of new project lab	14,00h - Closing conference
13,30-14,30h - Cocktail	
14,30-14,50h - Ice Rikalovski Green transformation for sustainable development of OKTA	
14,50-15,10h - Jadranka B Gilev - FTM-UCIM Polymer based green composites	
15,10-15,30h - Natasha Bakreska - TITAN USJE Green transformation for sustainable development of TITAN USJE	
15,30-15,50h - Emilija Fidanceski - FTM-UCIM Innovative inorganic materials for green transformations	
15,50-16,10h - Irena Mukaetova Velichkov (ALKALOID) Green transformation for sustainable development of ALKALOID	
16,10-16,30h - Darko Dimitrovski - FTM-UCIM Samples of valorization of waste & nus products from food production sector	

TOGETHER 4 CIRCULAR

Прва конференција за зелено инженерство, одржливи материјали и технолоогии за циркуларна економија

22 април 2024	23 април 2024
9,00 - 9,30 h - Регистрација	9,30 -10,00 h - Регистрација
9,00-9,30 h - Поставување на постерите	10,00-10,150h - Отворање на ХАКАТОНОТ
9,30 - 10,00h - Свечено отворање	10,15-10,45h - Презентација на ФИРМИ ФИРМА 1- РЕПЛЕК, ФИРМА 2 - М-Фашн, ФИРМА 3-ЗАВАР, ФИРМА 4- ТИТАН УСЈЕ, ФИРМА 5-ПАКОМАК, ФИРМА 6 - БИОНИКА, ФИРМА 7-САНДА
10,00-10,20h - Трајан Ангеловски (Претседател на Индустриска комора при Сојузот на Стопански комори) Поддршка на зелена и дигитална трансформација и академијата	10,45-11,00h - Презентација ТМФ ФИТР проект: Зелено и одржливо рециклирање на гумата / Марија Прошева
10,20-10,40h - Теодора Обрадовик (МОЕПП) Зелената Агенда и предизвиците за РС Македонија	11,00-13,00h - ХАКАТОН Одбрана на студентските идеи (5 мин презентација + 5 мин одгвори)
10,40-11,00h -Анита Котеска - Together4circular Зелено женско лидерство	13,00-13,45h - Кафе пауза
11,00-11,45h - Проф. Џејми Грунлан, Зелени и одржливи нанокомпозити за храна и заштита од оган	14,00 - 14,30h - Прогласување на победници
11,45-12,30h - Кафе пауза	
12,30-13,30h - Отворање нова лабораторија	
13,30-14,30h - Коктел	
14,30-14,50h - Ице Рикаловски - ОКТА Зелени трансформации за одржлив развој на ОКТА	
14,50-15,10h - Јадранка Б Гилев - ТМФ - УКИМ Полимерни зелени композити	
15,10-15,30h - Наташа Бакреска - УСЈЕ Зелени трансформации за одржлив развој на УСЈЕ	
15,30-15,50h - Емилија Фиданчески - ТМФ -УКИМ Иновативни неоргански материјали за зелени трансформации	
15,50-16,10h - Ирена Мукаетова (АЛКАЛОИД) Зелени трансформации за одржлив развој на Алкалоид	
16,10-16,30h - Дарко Димитровски Примери за валоризација на отпад и нус производи од прехранбената индустрија	

TOGETHER 4 CIRCULAR

GREEN AGENDA AND CHALLENGES FOR THE REPUBLIC OF NORTH MACEDONIA

Teodora O. Grnčarovska[1], Margarita Matlievska[2]

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The **external dimension of the European Green Deal** identified launching a Green Agenda for the Western Balkans as one of its key initiatives. The new all-encompassing EU growth strategy, based on decoupling economic development from resources use and greenhouse gas emissions can only be fully effective if the EU's immediate neighbourhood also takes action at an early stage. This is all the more valid for the Western Balkans given their European perspective and commitments to align with the evolving EU *acquis* as well as the 2030 Agenda and the Paris Agreement.

Together with the EU Heads of State or Government, the Commission has strongly reconfirmed its commitment to a **"green, digital and resilient" recovery**. Through Next Generation EU and a revamped EU budget, every euro of investment will be made available to get Europe back to its feet, to accelerate the twin green and digital transitions and build a fairer and more resilient society.

In the Zagreb Declaration (6 May 2020) the European Union (EU) and its Member States, in consultation with Western Balkans leaders, agreed to give a prominent role "to the association of the region to the EU's climate-related ambitions, in line with the Paris Agreement, to promoting the Green Agenda for the Western Balkans, as well as to furthering the digital economy and, strengthening connectivity in all its dimensions: transport, energy, digital and people-to-people, including tourism and culture". In this context, the Green Agenda for the Western Balkans need to be a **new vector of growth for the region** to turn sustainability and resilience challenges into economic opportunities. This can be done adapting the initiatives of the European Green Deal to the realities and the needs of the region, in a proportionate manner to ensure that Western Balkans take full advantage of their economic integration with the EU.

SUSTAINABLE POLYELECTROLYTE COATINGS FOR FLAME RETARDANCY, FOOD PROTECTION, AND HIGH VOLTAGE INSULATION

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Layer-by-layer (LbL) assembly is a conformal coating "platform" technology capable of imparting a multiplicity of functionalities on nearly any type of surface in a relatively environmentally friendly way. At its core, LbL is a solution deposition technique in which layers of cationic and anionic materials (e.g. nanoparticles, polymers and even biological molecules) are built up via electrostatic attractions in an alternating fashion, while controlling process variables such as pH, coating time, and concentration. Here we are producing nanocomposite multilayers (50 – 1000 nm thick), having 10 – 96 wt% clay, that can be completely transparent, stop gas permeation, impart extreme heat shielding to carbon fiber reinforced polymer composites. Similar films exhibit very high dielectric breakdown strength. In an effort to impart flame retardant behavior to fabric using fewer processing steps, a water-soluble polyelectrolyte complex (PEC) was developed. This nanocoating is comprised of polyethylenimine and poly(sodium phosphate) and imparts self-extinguishing behavior to cotton fabric in just a single coating step. Adding a melamine solution to the coating procedure as a second step renders nylon-cotton blends self-extinguishing. A PEC of PEI and polyacrylic acid is able to achieve an oxygen transmission rate below 0.005 $cm^3/m^2/day$ at 100%RH and a thickness of just 2 ▪m. These coating techniques can be deposited using roll-to-roll processing (e.g., flexographic printing, dip-coating, or spray-coating). Opportunities and challenges will be discussed. Our work in these areas has been highlighted in *C&EN*, *ScienceNews*, *Nature, Smithsonian Magazine, Chemistry World* and various scientific news outlets worldwide. For more information, please visit my website: http://nanocomposites.tamu.edu.

GREEN LEADERSHIP

Anita Koteska

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Together4green acelerator

Female Green Leadership is a set of skills.
A green leader embodies a unique **set of** qualities that prioritize environmental stewardship, inspire others, and drive sustainable change. Leaders were always meant to be visionaries, but with sustainability, it's a critical skill. They combine environmental awareness, strategic vision, collaboration, and advocacy, in order to make a positive impact on the planet.

Women have been socialized to be strong but also practical. In many societies, they are expected to make things work, but not in a stagey way. Their aim is results, not glory, that's why they are born to be green leaders by nature!

A Green Leadership implies sharing environmental knowledge and sustainable performance, empowering lots of people, not focused on one individual. The role of the leader is (or should be) to help every party member, and every member of the society, to be a leader, through mentorship, support and business advice.

Green leadership as a concept has emerged consequently to sustainability. Taking into consideration that sustainability is now being integrated across the organization as an important part of growth strategies, where the companies doesn't need managers only!

They need green leaders!

Because this is a relatively new function, developing best practices and accumulating knowledge are becoming imperative in terms of sustainability

While sustainability is becoming a central strategy inside the company, green leadership is becoming more necessary to guide this process and to solve the issues aligned with the growth strategy. As more companies realize that this is a major competitive issue, they're looking for leaders to drive their efforts. Green leadership implies systematic thinking, combining.

Key words: female green leader, set of skills, leadership, sustainability, environmental, empowering.

POLYMER BASED GREEN COMPOSITES

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Lignin is an important aromatic renewable natural resource today, serving as a sustainable, environmentally acceptable alternative feedstock to fossil-derived chemicals and polymers in a wide range of value-added applications. It is a biopolymer molecule that can be extracted from pulp and paper industry byproducts, agricultural waste and residues. The characteristics of lignin allow the creation of green composites with high added value. Lignin-based materials are usually environmentally friendly and low-cost, and are widely used in hydrogels, 3D-printing-based lignin, new sustainable biomaterials, environment, sustainable bioenergy production technologies, such as the supercapacitor electrode, photocatalysts, and photovoltaics.

Within this research work, lignin-based polymer composites were synthetised by in-situ miniemulsion polymerization. Emulsion polymerization in which water is used as a polymerization medium is not only an environmentally acceptable method, given that the use of volatile organic components is reduced, but it is also economically viable. In the scope of this research, the antioxidant influence of lignin was investigated in the direction of increasing the photostability of composites with lignin concentration based on monomers from 1 to 3 wt%. The spectra obtained by UV-Vis spectroscopy indicated that the addition of lignin leads to a shift of the absorption maximum of the composites to a higher wavelength and increment of the absorption of visible light. Results from FTIR spectroscopy suggested that the composites with 3 wt% concentration of lignin have undergone the least chemical changes after UV irradiation. This antioxidative influence of lignin is due to the phenolic structure that successfully traps free radicals and prevents the formation of new radicals, thus increasing the stability of the polymer composites.

Key words: lignin, waterborne composites, UV stability.

GREEN TRANSFORMATION FOR SUSTAINABLE DEVELOPMENT OF TITAN USJE

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Following the TITAN Group strategy, USJE is focused on achieving operational excellence in all areas of our work, including accomplishing excellent results when it comes to the environment, social impact, and good governance.

Given that climate change is the highest priority on a global scale, Cementarnica USJE and TITAN Group contribution towards its mitigation is reflected in our decarbonization activities. Our decarbonization strategy includes a comprehensive set of levers to reduce emissions of cement production, while offering new innovative products to our customers that meet their needs for durable and sustainable building materials. In 2023, our pozzolanic eco cements that combine superior performance and lower carbon footprint, became the best sellers.

By applying the circular economy approach, we contribute to reducing the carbon intensity of our cement production process by replacing fossil fuels with alternative fuels, i.e. materials that cannot be reused and biomass as well. By using alternative fuels, we also contribute to decreasing the amount of waste that is disposed at landfills and at the same time recovering their heat value.

Our company succeeds in promoting energy efficiency, increasing the use of renewable energy and reducing greenhouse gas emissions. In that respect we commissioned the photovoltaic plant with installed power of 3 MWp. This major project in Cementarnica USJE is planned to substitute around 10% of the daily electricity consumption of the plant by renewable energy.

All these efforts include building strong bridges with our business partners and suppliers, as well as with institutions and the local community.

Key words: decarbonization, renewable energy, eco cements, alternative fuels, sustainable production.

INNOVATIVE INORGANIC MATERIALS FOR GREEN TRANSFORMATION

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Thermal power plant REK Bitola still dominates the electricity market in Republic of North Macedonia. As a result, huge quantities of coal fly ash (CFA) have been stored in landfill, thus presenting the source of environmental pollution.

Following the concept of circular economy, CFA presents a valuable by-product with potential to be used as secondary raw material in existing applications: as road construction material, soil amelioration, zeolites, adsorbents, civil engineering materials (cement, concrete, light-weight aggregates, bricks, tiles, glass-ceramics, etc.). Nowadays, due to the new technologies its utilization is much wider in the sense of its green transformation. For instance, fly ash can be used for nanomaterials synthesis (carbon nanotubes), aerogels, geopolymers, rare earth elements recovery and catalyst.

The potential challenges and opportunities for valorizing fly ash (REK Bitola) as secondary raw material (mainly due to its physical and chemical characteristics) for innovative realization will be discussed based on the up-to now realized research activities. Fly ash (REK Bitola) has potential to be used not only in cement (as it is up to now), but for more innovative materials mostly in civil engineering in our country.

Working out on the strategies and applied research for increasing the utilization rate of fly ash, will undoubtedly result in numerous economic and environmental benefits and make Pelagonia better and more sustainable region.

Key words: coal fly ash; green transition, by-product, circular economy, REK Bitola.

NAVIGATING THE GREEN PATH: CLIMATE ACTION AND DEPOLLUTION CHALLENGES IN NORTH MACEDONIA

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Macedonia's aspiration to join the European Union necessitates aligning national policies with those of the EU, particularly the Green Agenda for the Western Balkans, a derivative of the European Green Deal.

This Paper is focused on two main objectives: the first aims to analyze the process of developing Macedonian National Action Plan for Green Agenda (NAPGA), identify challenges associated with its coordinating and offer recommendations. The second objective is to examine areas concerning climate action and depollution taking into account regional priorities, and providing recommendations accordingly. Thus, this paper explores two primary aspects:

Firstly, it delves into the development process of the Macedonian NAPGA, crafted in response to the Green Agenda for the Western Balkans. Through the process of setting the matrix which matched national with regional priorities, and by conducting interviews with representatives from key ministries involved in the process, the study proposes the vision and mission of the NAPGA. Further on, strategic sectoral priorities across all five pillars: decarbonization, depollution, circular economy, sustainable agriculture, and biodiversity protection were set.

Secondly, for the purposes of showcase, climate action sub-pillar and depollution pillar were in-depth analyzed aiming to identify the challenges therein. The research offers a comprehensive overview of the current status and identifies areas requiring attention on the national level in this two researched areas.

In the concluding remarks the Paper navigates actions needed for implementation modalities of such a complex processes and to cope with regional priorities at national level in climate action and depollution.

Key words: green transition, green agenda, depollution, climate change.

ADVANCEMENTS IN MULTIMETAL MULTIVALENT OXIDES FOR SUSTAINABLE ENERGY STORAGE AND CONVERSION: A FOCUS ON OXYGEN REDUCTION AND EVOLUTION REACTIONS

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The paper investigates the synthesis and characterization of potential catalysts for oxygen reduction (ORR) and evolution (OER) reactions utilizing Ce, Y, Yb and Co. Employing the ultrasonic spray pyrolysis (USP) synthesis method, multivalent oxides were successfully synthesized from metal salts precursors, exhibiting promising catalytic properties for ORR. The research outlines experiments: microwave synthesis, IrO_2 deposition and various techniques and electrochemical analyses (XRD, SEM/EDS, CV, LSV, PEIS, C-DC), illustrating the performance of multivalent oxides for OER. Additionally, the study emphasizes the significance of rare earth elements (REEs) in advanced technology manufacturing and investigates the potential of coal fly ash (CFA) as a resource for REE extraction. The paper proposes innovative approaches for REE recovery from CFA waste, aligning with circular economy principles and sustainable resource management strategies. It underscores the importance of local extractive technologies to mitigate transportation costs and environmental impacts, thereby contributing to regional resource independence and environmental sustainability. This research aims to provide valuable insights into the development of efficient catalysts for ORR and OER, fostering the transition towards a more sustainable and prosperous future in energy storage and conversion technologies. The results demonstrate the superior catalytic activity of the synthesized multivalent oxides compared to conventional catalysts, highlighting their potential for practical applications in rechargeable metal-air batteries and fuel cells.

Key words: multivalent oxides; oxygen reduction reaction; oxygen evolution reaction, sustainable energy storage; circular economy.

CIRCULAR ECONOMY FOR METALLURGICAL WASTE FROM FERRONICKEL INDUSTRY

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The subject of this work is studying the use of industrial, solid waste materials from ferronickel industry (fly ash – FA, electric furnace slag – EFS and converter slag – CS) as a raw material for glass-ceramic production and as reinforcing component in new value added polymer based composite – eco-friendly, functional geo-membranes. Characterization of the solid wastes was done by means of XRD, TGA and standard leaching test.

The solid wastes from ferronickel smelting plant were mixed with glass cullet and were vitrified for 2 hours at 1400 °C. The obtained glass was studied by DTA analysis in order to optimize two step heat-treatment for its transformation to glass–ceramic with enhanced properties. The SEM analysis, measurements of mechanical properties and leaching test was performed.

Geo-membranes were produced by film-casting method using polyvinyl chloride (PVC) matrix reinforced by the previously mentioned metallurgical waste materials, as-prepared and modified in acid (HCl) and alkaline (NaOH) medium. The study of the produced geo-membranes was done related to their morphology and internal structure (SEM observation and FTIR analysis), thermal stability (TG/DTA/DTG analysis) and moisture stability (followed kinetics of swelling was determined and the ultimate rate of swelling after 24 hours).

Key words: fly ash, electric furnace slag, converter slag, glass-ceramic, geomembranes.

RECYCLING AND REUSE OF NATURAL FIBER REINFORCED ECO-COMPOSITES INTO POLYMER MORTARS FOR LOW-COST CONSTRUCTION SECTOR

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During the last few years the potential of natural fibre-based polymer composites has received considerable attention, due to their promising specific properties and for both economic and environmental benefits in global trend toward sustainability. However, one of the biggest problems facing mankind recently is the environmental pollution resulting from industrial wastes and waste living materials. So, the reuse of waste materials, including polymer based composites, especially thermoplastics-based ones, for different fields of application, is being widely encouraged from the viewpoints of environmental protection and resources exploitation.

In the framework of the ECO-PCCM project (ECO-PCCM, FP6-INCO-CT-2004-509185) development and design of recycling-reuse facilities for transformation of solid–polymer composite waste into polymer mortars and concrete structures for the low-cost building industry was performed. Thermoplastic polymer matrix based composites reinforced with natural fibers (rice straw and kenaf fibers) have been recycled and reused as reinforcement of polymer mortars based on PES resin. The obtained materials have been analyzed with standard test methods such as mechanical tests, TGA, DSC and SEM. The obtained results have been compared with conventional mortars.

Key words: polymer mortars, eco-composites, reuse.

FLAY ASH/CHITOSAN COMPOSITES AS ADSORBENT OF HEAVY METAL IONS

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Water contamination is a serious problem and increase the concern because of its effects on living organisms as well as the surrounding environment. Due to the problems created by the inclusion of heavy metal ions - HMIs in wastewater, traditional wastewater treatment techniques such as adsorption, coagulation, flocculation, precipitation, reverse osmosis, biological process, gamma radiations, and photo catalysis were used to remove them.

The subject of this work was to obtain and to test the Fly ash/Chitosan composites aimed for HMI adsorption in polluted waters. Three different types of fly ash waste particles were used, two types supplied from EURONICKEL and one supplied from OSLOMEJ, Macedonia. The surface of the fly ash (FA) particles was modified by treated with nitric acid. Several types of composite adsorbents were prepared using the chitosan as a polymer matrix. The characterization of the FA waste particles was performed by XRF, XRD, TGA, SEM and FTIR analysis, while the obtained composites were tested by TGA, SEM and FTIR analysis. It was found that the structure, morphology, and thermal properties of FA particles were significantly changed and it was expected that it will improve their adsorption capacity. FA/Chitosan composites were tested as an adsorbent for Cu (II), and Pb (II) from aqueous solutions. The effect of contact time, solution pH, initial metal concentration was studied in batch experiments. Maximum metal sorption was found to occur at pH 6.0. The equilibrium adsorption data for Cu (II) and Pb (II) ions were fitted to Langmuir isotherm model. The efficiency trend was Pb (II) > Cu (II). The results indicated that the removal efficiency for Cu (II) and Pb (II) ions was 91.1% and 99.7% respectively.

Key words: fly ash, composites, adsorbents, heavy metal ions.

ECO-INNOVATION - BIODEGRADABLE KIKI BOX

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The aim of this work was to demonstrate revalorization of bio-waste material - peanut shells as a filler in biodegradable polymer matrix of Polylactic acid or eco-friendly, recyclable polymer such as Polypropylene. New product, called KIKI box was aimed for one-year seedling of flowers.

New product was produced on conventional machines for polymer processing. It was characterized with good mechanical properties and morphology of the structure. Eco-indicators were calculated and they confirmed the lower environmental impact of the new product.

Biodegradable KIKI box has received silver medal on MAKINOVA'12 in Skopje and silver medal Nikola Tesla on the Balkan innovation fair 2013 in Belgrade.

Key words: eco-innovation, biodegradable polymer, peanuts.

APPLICATION OF NANO ZERO-VALENT IRON IN HEXAVALENT CHROMIUM-CONTAMINATED WATER

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Hexavalent chromium is a highly toxic form of chromium and it can have harmful effects on human health and the environment. Contaminated groundwater with Cr(VI) is a significant environmental problem. Nano zero-valent iron is an effective material for the degradation or immobilization of contaminants in groundwater and soil. In this study, nano zero-valent iron was applied to reduce Cr(VI) in an aqueous solution. The influences of different operating parameters on the reduction process were analyzed and the optimal conditions were found. The response surface methodology was employed to optimize the process. The created model adequately fitted experimental data with a correlation coefficient of 0.9446 and a mean absolute error of 0.05799. The created Pareto chart showed that the contact time had the highest statistically significant effect on the Cr(VI) reduction efficiency. An optimal reduction efficiency was achieved at a pH of 5.0, an initial concentration of nano zero-valent iron of 90 mg/L, and a contact time of 253 min.

Keywords: nano zero-valent iron; Cr(VI)-contaminated water, process optimization.

ANN MODELING OF A CONTEMPORARY SEPARATION SYSTEM FOR LYCOPENE RECOVERY FROM TOMATO BIOWASTE

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This study is based on the potential valorization of tomato industry peels that are being discarded as by-products and bio-waste. Dried tomato peels matrixes were investigated as a natural source of lycopene. The experimental plan was conducted employing the contemporary Microwave-assisted extraction (MAE) technique for the designated extraction process that was performed at operational range of experimental variables of microwave power of 120, 230, and 385 W and extraction time of 2, 5, 8, and 10 min. The lycopene presence in the total extract obtained using appropriate solvent systems was quantified by UV/Vis spectrophotometer. The absorbance at 501 nm was selected for the determination of lycopene content and the calculation of lycopene yield (mg/100 g). Feedforward artificial neural network (ANN) model with architecture 2-10-1, trained using a backpropagation algorithm was developed for predictive modeling of the lycopene yield obtained through the MAE process. The resulting model produced a high correlation of output modeled values to the experimental data (R^2>0.99) and low mean squared error (MSE<0.5). The response surface methodology (RSM) was successfully introduced to generate the functional dependency of the studied ANN model output to independent experimental variables of the MAE process (R^2≈0.95). The analysis of experimentally generated results regarding the lycopene yield as a designated output depicts a complex effect of evaluated input parameters and their interactions. Resulting 3D response surface generates process efficiency optimum of 27.25 mg lycopene/100g dried tomato peels, obtained at 324 W and 8,6 min.

Key words: lycopene extraction, microwave assisted extraction, ANN predictive modeling.

MACHINE LEARNING IN UNRAVELLING OPTIMAL PARAMETERS FOR CNTs AND GRAPHENE GREEN PRODUCTION

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Machine learning plays a key role in this work, designing novel green technologies for producing carbon nanotubes (CNTs) and graphene by electrolysis in molten salts. The aim is to achieve non-expensive, high-quality materials, making them economically viable for various applications. For the production of multi-walled carbon nanotubes (MWCNTs), experiments employ both non-stationary and stationary current regimes, while for graphene production, constant and reversing cell voltage as well as constant and reversing overpotential methods are considered. The electrolysis process offers green as well as economic advantages with precise control over parameters such as applied voltage, current density, temperature, electrolyte type, and graphite material. To determine the relationship between these parameters and material quality, explainable tree-based Machine Learning (ML) models are employed, trained using labeled data from domain experts. The extracted rules from the ML model guide optimal production, resulting in high-yield materials that are up to ten times more cost-effective and green. The latter contributes to the advance of cost-efficient and high-quality carbon nanomaterials for a wide range of applications.

Key words: machine learning, green technology, graphene, CNT.

APPLICATION OF THE CIRCULAR ECONOMY CONCEPT IN CONSTRUCTION AND ARCHITECTURE

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Applying the concept of circular economy and adhering to circular economy guidelines is a lot more than reducing or recycling waste. By using recycled material, i.e. reusing materials reduces the use of natural resources and the generation of waste. The paper describes the acceptance of the idea of a circular economy in construction, which reduces the total use of resources during the lifetime of buildings. It is about fundamentally rethinking the way buildings are designed, built, and used, allowing for a longer building life, where a return to processes such as depreciation and demolition is avoided. As the global population has doubled since 1970, resource use has tripled to meet demand, which continues to grow. This demand is best seen in the construction industry, which with increasing urbanization and rapid development of cities, leaves a huge mark on the natural environment. It is estimated that the circular economy in construction, by moving to a completely zero-emission regime, could significantly reduce the global CO_2 emissions that this industry leaves behind. The transition to a circular economy is accompanied by the saving of resources, the reuse of the built environment, as well as the creation of new specializations and new jobs. Careful management of materials and resources would enable greater savings in the production chain, lower fuel consumption, lower CO_2 emissions, less construction waste, and a healthier and cleaner natural environment for everyone.

Key words: circular economy, building materials, recycling, construction waste.

THE ROLE OF TEXTILE RECYCLING IN THE CIRCULAR ECONOMY MODEL

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The circular economy leads large companies to change their way of doing business and introduce measures to reduce the negative impact on the environment. Likewise, the circular economy leads individuals to reconsider their attitude towards waste. For the circular economy model to come to life, it is not enough to take care of waste management only within companies, it is also very important that each individual contributes. As raw materials are increasingly scarce and materials are increasingly expensive, the operational management of material flows is becoming increasingly important for companies. By moving from a linear to a circular business model, we face technological, structural, and personnel changes and challenges. The circular economy must strive to achieve sustainable development at the global level, which should represent a profitable economic system that will enable consumers not to endanger the environment when using products. All these goals can be achieved by extending the life of the product, but also by recycling. The application of a circular economy model in which waste is viewed as a strategic raw material is one of the ways to ensure the long-term supply of raw materials in the textile sector. The paper analyzes the state and chances of successful and efficient operation of the textile and clothing industry of Serbia by creating a new raw material base, where special attention should be paid to the economic and ecological aspects of efficient operation, i.e. there should be a concept of cost-effective processing of textile waste. In the context of the circular economy model in the textile sector, special emphasis must be placed on the creation of new jobs that arise in the process of textile recycling.

Key words: circular economy, waste, waste management, textile industry, textile recycling.

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ECO-FRIENDLY NONWOVEN COVERS FOR AGRICULTURE USE PRODUCED FROM POST-CONSUMER WASTE – COTTON T-SHIRT

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The global rise in population and growing demand for high-quality crops are the main challenges for agrotextiles improvement. The world needs more sustainable and eco-friendly nonwoven crop covers to replace the use of synthetic nonwoven crop covers to prevent pollution. The article considers the problem of processing textile waste from the post-consumer sector (PCW). The main directions of their use in producing nonwoven fabric are briefly described. The use of post-consumer textile waste (PCW) based on used cotton T-shirts in the manufacture of nonwovens by wet laying process using the circular economy principle is considered. Samples of nonwovens were obtained and characterized through thickness, mass per unit area, mass per unit volume, and linear density, and the attained results were compared with those for a commercially available PP nonwoven intended for crop covers. The mass per unit area of the developed nonwoven fabrics was higher than the commercially available PP nonwoven fabric intended for crop covers, wherein the developed nonwoven fabrics exhibited 27 g/m^2 while the commercially available PP nonwoven fabric intended for crop covers showed a value of 17 g/m^2. The thickness and linear density of developed nonwoven fabrics were also higher than the commercially available PP nonwoven fabric intended for crop covers, but the mass per unit volume is very similar to commercially available PP nonwoven fabric intended for crop covers. The coefficient of variation in the thickness of the obtained materials is about 10%. The obtained materials can be used in the manufacture of crop covers in agriculture.

Key words: nonwoven, post-consumer waste, cotton, used T-shirt, agrotextiles.

SOLAR ENERGY APPLICATION FOR WEAVING PRODUCTION

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Textile industry is manufacturing encompassing heterogeneous and fragmented processes such as fiber production, spinning, weaving, dyeing, finishing and sewing. Each process has different energy consumption from energy intensive spinning and weaving to less energy demanding process like sewing. Moreover, operations within the same process can require different amounts of energy. Clean energy sources are finding increasing application in the textile industry, particularly solar panels.

The objective of this research is to examine the influence of introducing solar energy in the weaving industry. Details on energy productivity were given by commercial software (Fronius), on daily and monthly bases, while energy consumption was calculated from machine specifications and actual total consumption. The main challenge in using solar energy is the variation in energy production throughout the year, as increased solar radiation, leads to higher energy production. This entailed that the winter production of energy was 23.9% of the summer energy production. To address the seasonal variability in energy production, the technological process can be planed according to anticipated solar radiation. Weaving is a discontinuous process, where operations for weaving preparation can be separated from the weaving operation itself. Therefore, operations with high energy consumption such as winding can be performed in the summer months, while necessary machine maintenance can be allocated in the winter period.

In conclusion, the weaving process can be optimized according to energy production by adjusting yearly and weekly production to climate conditions.

Key words: sustainability, textile industry, solar energy.

CHANGES IN THE CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF YOGURT ENRICHED WITH CHIA SEEDS

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The aim of this paper is to investigate chemical, microbiological and sensory properties in yogurt samples enriched (fortified) with honey and different amount of chia seeds at ratios (5% and 10%, w/w) during storage (at 5±1°C for 1, 7, 14 and 21 days. From the conducted analysis, it has been determined normally decreasing the pH and increasing the titratable acidity of yoghurt samples during storage. The fat content remains the same during the storage period of the yogurt samples. The addition of chia seeds to the yogurt significantly increases the content of the proteins ($p < 0.05$) with increasing the chia seed content in the yogurt. The yoghurt containing 5% chia seeds has the highest total viable lactic acid bacteria count compared with plain yoghurt and other chia concentration during the storage. Enterobacteria, yeast and molds, coagulase-positive staphylococci, Salmonella and Listeria monocytogenes were not detected in all yoghurt samples after 21 days of storage. According to sensory evaluation, yogurt sample with 5% chia seeds has the highest scores compared with plain yoghurt and other ratio of chia seeds.

Key words: yogurt, chia seed, storage, sensory analysis.

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CONSUMER`S PERCEPTION ON FOOD BY-PRODUCTS AND THEIR USE IN EU AND NON-EU COUNTRIES

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The aim of this paper should be is to ascertain consumer perceptions on the composition of food by-products and their application in both non-EU countries (R.N Macedonia and Bosnia and Herzegovina) and EU countries (Bulgaria and Croatia). Questionnaire methodology was used to reach the objectives of this research that was available on the Google platform. The survey was contained 15 questions. The survey was anonymous and completed by a total of 419 people (107 Bulgaria, 105 Croatia, 103 R.N. Macedonia and 104 Bosnia and Hercegovina). More than half of the respondents in each country consider that managing waste from food industry is not proper and most often this waste is processed through its biological decomposition. More than 70% of the respondents have not found products which contain waste from the food industry, but if this type of product was to be presented on the market, they would choose it. About composition of the waste from the food industry the respondents indicated that this type of waste contains most biologically active substances, as well as dietary fiber. Regarding the place of residence, more than half of the respondents pointed out that waste produced in wine production contains the highest amount of polyphenols, waste produced when processing apples contains the most dietary fiber, and waste produced from tomato processing contains carotenoids.

Key words: food waste, by-products, consumer perception

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BIOPROTECTIVE CULTURES AND REDUCTION OF WASTE AT DAIRY PRODUCTS

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This study investigates the application of commercial bioprotective cultures in mitigating premature microbial spoilage and extending the shelf life of set yogurt, thereby addressing the critical issue of food loss and waste, particularly in the dairy sector. Physicochemical, technological, and sensory properties of yogurt inoculated with bioprotective cultures were evaluated alongside a control group throughout a 35-day refrigerated storage period in a laboratory conditions. Results indicate that incorporating bioprotective cultures significantly impacts the physicochemical attributes of yogurt, including pH, titratable acidity, water holding capacity, and diacetyl concentration, with notable improvements observed in taste and aftertaste. While both control and bioprotective batches exhibited a decrease in pH and an increase in acidity during storage, the bioprotective set yogurt sample showed enhanced freshness and naturalness, as perceived by sensory evaluations. Microbiological analysis at the end of the storage period detected the presence of yeast and molds in both batches, with a higher prevalence observed in the control samples. This research underscores the significance of exploring multifaceted approaches to tackle food loss and waste, highlighting the potential of bioprotective cultures as a viable solution in dairy product preservation.

Key words (up to 5 words): set yogurt, bioprotective cultures, waste, dairy

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SENSORY ACCEPTANCE OF TOMATO POMACE ENRICHED CRACKERS

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The food industry processes approximately 37 million tons of tomatoes globally, with a significant portion used to produce tomato paste for various products like soups, sauces, and ketchup. Industrial waste from tomato processing poses challenges, requiring efforts to utilize valuable by-products effectively. These by-products, comprising 10-30% of processed tomatoes, include seeds, peel, pulp, and cores rich in bioactive compounds like dietary fiber, protein, oil, minerals, phenolic compounds, and carotenoids.

Tomato peel, rich in biologically active compounds, can be incorporated into crackers as an alternative food source which are a widely consumed snack in the human diet. By utilizing waste from the tomato industry, functional snacks with enhanced nutritional value can be developed, while simultaneously addressing the environmental challenge of pollution reduction. This approach not only promotes sustainable practices in the food industry but also provides a novel way to utilize tomato by-products for their nutritional benefits.

This study explores the sensory attributes of functional crackers prepared with tomato pomace, a by-product of the ketchup production industry. The sensory profile and overall acceptability of 13 biscuit samples with three distinct granulations (1mm, 0.5mm, and 0.25mm) of tomato pomace were evaluated as wheat flour substitutes at four different percentage levels (2.5%, 5%, 7.5%, and 10%). Sensory analysis was conducted in the food laboratory at the Faculty of Technology and Metallurgy in Skopje under controlled conditions by 50 untrained evaluators. This research aims to assess the sensory characteristics of functional crackers incorporating tomato by-products and their potential as a nutritious and sustainable food ingredient.

Key words: tomato pomace, functional crackers, food waste, circular economy, sensorial characteristics.

BIOPOLYMER-BASED INTELLIGENT PACKAGING WITH ANTHOCYANIN EXTRACT FOR SUSTAINABLE FOOD MONITORING

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Intelligent packaging systems have gained a significant attention over the past few years, due to their ability to monitor the freshness and quality of the food products. This study focuses on developing chitosan and starch based biopolymer films with addition of anthocyanin extracts derived from purple cabbage. This innovative approach not only improves the functionality of the packaging, it also contributes to sustainable practices in the field of green engineering. The packaging consists of biopolymers as base material, ensuring biodegradability and environmental friendliness. The addition of anthocyanins extracted from purple cabbage waste adds another layer of eco-friendliness, effectively reusing food by-products and minimizing waste. The working principle of the pH indicators consists of detecting the changes of concentration of various organic acids, which results in color changes of the sensor. As the products are deteriorating, the color of the film changes and the consumers get real-time information about the current state of the packaged food. By embracing green engineering principles and contributing to the circular economy, this innovative packaging solution holds promise for enhancing food quality monitoring while simultaneously promoting sustainability in the food industry.

Key words: intelligent packaging, sensors, anthocyanins, sustainability.

DESIGN OF PHOTOBIOREACTOR LIGHTING SYSTEM

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Photobioreactor (PBR) represents a promising platform for cultivation of phototrophic bacteria which possess unique capabilities for utilizing organic matter from waste or industrial by-products while generating high value products. This study introduces a novel lighting system integrated into a PBR design, consisting of LED diodes emitting green, orange, and infrared light. The intensity of the lights and the duration of the emission are controllable by the user through specifically developed software, allowing for precise manipulation of growth conditions. By harnessing the specific wavelengths and intensities of light, this innovative PBR configuration facilitates optimal photosynthetic activity and metabolic processes. The customizable illumination parameters offer flexibility in adapting to the specific requirements of bacterial growth, enabling efficient biomass production and metabolic activity. Moreover, the user-friendly interface of the control unit simplifies operation and monitoring of the PBR system, enhancing accessibility for researchers and practitioners in the field of biotechnology. This integrated approach to lighting control ensures consistent and reproducible cultivation conditions, facilitating research and development efforts aimed at harnessing the potential of phototrophic bacteria for various applications, including biofuel production, wastewater treatment, and bioremediation. Overall, the combination of advanced lighting technology and bacterial cultivation in PBRs holds promise for sustainable bioprocesses that leverage organic matter utilization, contributing to the advancement of renewable energy production and environmental sustainability.

Key words: Phototrophic bacteria, cultivation, photobioreactor, lighting system.

VALORIZATION OF BREWERY SPENT GRAINS FOR THE PRODUCTION OF SHORT-CHAIN FATTY ACIDS

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Brewer's Spent Grain (BSG), constituting 85% of brewing industry's solid bio-waste, is a by-product rich in nutrients including lignocellulosic fibers, proteins, fats, and minerals. Traditionally used as animal feed or compost, a big portion of BSG ends up in landfills, presenting environmental risks. In alignment with circular economy principles, alternative valorization strategies for BSG are being explored, including its use for the production of energy and value-added products or nutrient extraction. In this context, a notable valorization approach related to high value products is converting BSG into short-chain fatty acids (SCFAs) via anaerobic fermentation (AF), which involves breaking down its organic components into monomers that are further transformed into SCFAs and gases. Therefore, SCFAs production from both raw and pretreated (autoclaved) BSG was evaluated in two continuous stirred tank reactors, run in parallel under identical operational conditions, using anaerobic inoculum from a wastewater treatment plant. Process monitoring involved bi-weekly gas and liquid samples analysis to assess the AF performance in terms of SCFAs concentration, profile, and efficiency, including bioconversion, acidification, and hydrolysis yields. The findings highlighted the potential of AF not only for waste reduction but also in generating valuable compounds (SCFAs) with broad applications in the pharmaceutical, food, and textile industries, as well as supporting circular economy initiatives.

Keywords: brewery spent grains, circular economy, short chain fatty acids, anaerobic fermentation.

DEVELOPMENT OF CHROMATOGRAPHIC METHODS THROUGH THE LENS OF GREEN CHEMISTRY

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Reverse-phase high-performance liquid chromatography (RP-HPLC) is one of the most commonly used techniques in pharmaceutical analysis, playing a fundamental role in the pharmaceutical industry. The conventional LC methods often use large quantities of toxic organic solvents for sample preparation and as part of the LC mobile phase. The increasing awareness, but also the concern about the negative effects of chemicals and chemical waste generated from the conventional chromatographic methods have led to the adoption of green analytical chemistry (GAC) principles in pharmaceutical analysis. Green LC, a part of GAC, is aimed at finding new eco-friendly organic solvents to replace harmful ones, with the goal of creating sustainable chromatographic methods.

In this research, several sustainable RP-HPLC methods for quality control of medicinal products were developed. Greening of the LC methods was achieved by replacing toxic solvents (acetonitrile and methanol) with ethanol, as the most preferred green solvent. In addition, the reduction of the solvent consumption was introduced with the use of smaller solvent quantities for the sample preparation process. The methods were validated according to the ICH guideline and applied for quality control of the medicinal products. The evaluation of the methods' greenness features was performed using the Eco-scale index, the AMGC calculator and the Analytical GREEnness metric. The sustainability ("whiteness") of the proposed RP-HPLC methods was confirmed using the RBG 12 algorithm.

The findings confirmed that the ecological aspects of the chromatographic method can be improved, while preserving/improving the required analytical and economical attributes of the method.

Key words: green analytical chemistry, eco-friendly chromatographic methods, pharmaceutical analysis, greenness assessment.

PHYSICOCHEMICAL CHARACTERIZATION OF GOLD NANOPARTICLES BIOSYNTHESIZED USING *Rubus spp*. LEAVES EXTRACT

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Biomolecules play a major role in the process of biosynthesis and formation of gold nanoparticles (AuNPs). The process itself depends on the nature of the plant extract used. Green synthesized gold nanoparticles stabilized by aqueous extract of blackberry leaves obtained by maceration and synthesized at room temperature were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray (EDX) spectroscopy, dynamic light scattering (DLS) and zeta potential. XRD analysis shows the crystal structure and confirms that the peaks of the synthesized nanoparticles with 2θ at about 38.2°, 44.4°, 64.6, 77.5° and 81.8° correspond to the reflection planes (111), (200), (220), (311) and (222), respectively, of which the (111) plane is the most intense. Two important parameters characterizing the properties of nanoparticles are size and shape. The average crystallite size of synthesized AuNPs was 17.4 nm. SEM analysis showed that the shape of the gold nanoparticles in this sample is mostly cubic in appearance. EDS spectra showed the formation of AuNPs via peaks at around 2.2 keV, the highest signal corresponds to elemental gold, while signals of lower intensity indicate the presence of chlorine, most likely originating from chloroauric acid. The average zeta potential value was 11.6 mV, while the average particle size was 93.97 nm. The average value of mobility and conductivity was -0.9146 μmcm/Vs and 0.0879 mS/cm, respectively. Further studies of synthesized AuNPs should be conducted within the dermal and cosmetic preparations design.

Key words: gold nanoparticles, *Rubus spp*. leaves, characterization

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Hypericum perforatum L. - MEDIATED GREEN SYNTHESIS OF SILVER NANOPARTICLES

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Hypericum perforatum L. has been used as a traditional medicinal plant all over the world, due to its large diversity of secondary metabolites with considerable pharmaceutical effects. *H. Perforatum* exhibits analgesic, anti-inflammatory, antioxidant, antidiabetic, and cytotoxic activities. Silver nanoparticles (AgNPs) are significant particularly because of their physicochemical and antimicrobial properties which help in molecular diagnostics, therapies, and devices used for medical processes. In the current study, the water-diluted methanol extract of *H. Perforatum* obtained by maceration was used to synthesize silver nanoparticles at two different temperatures (room and boiling), as an environmentally friendly, fast, and clean method. The synthesis of silver nanoparticles was performed using an aqueous solution of $AgNO_3$ in the concentration of 0.001 mol/dm^3. The concentration of methanolic *H. Perforatum* extract obtained by maceration was 19,8 mg/ml. The molar ratio of extract and silver nitrate during the synthesis was set to 1:1. The formation of silver nanoparticles was monitored by continuous measurements at UV-VIS spectrophotometer. The chemical composition of the extract was investigated by LC-MS analysis. The presence of hypericin, pseudo-hypericin, hyperforin, and flavonoids in *H. perforatum* extracts and low polar compounds on the surface of NPs contributes to their antioxidant and antibacterial activities. The change in color and appearance of band at ~425 nm in UV-VIS spectra, shows that the synthesis was successful and silver nanoparticles were formed.

Key words: Silver nanoparticles, *Hypericum perforatum* L., UV-VIS, LC-MS

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ANTIOXIDANT ACTIVITY OF GRAPESEED OIL FROM MACEDONIAN VRANEC - *Vitis vinifera* L.

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Grape (*Vitis vinifera* L.) is one of the most widely grown fruit in the world. The cultivation and processing of grapes involves the production of large quantities of by-products such as grape marc, grape seed, grape skin, grape stem and grape leaf. Grape seeds contain 8–20% oil, which is rich in mono- and polysaturated fatty acids. Phytosterols are lipophilic molecules in grape seed oil and the biological importance of phytosterols lies in their antioxidant activity. Phenols have antioxidant effects and are present in grapes.

In this study, grape seed oil was produced from grape variety Vranec using Soxhlet and ultrasonic extraction. The aim of this work was to compare the antioxidant capacities of oil yield obtained by different extraction methods. The fatty oil was isolated by Soxhlet and ultrasonic extraction using *n*-hexane as extragens (solvomodule 1:10 m/V). Antioxidant potential was estimated by using the DPPH assay. The qualitative composition of fatty oil was determined by FT-IR analysis. The yields of fatty oil obtained by Soxhlet and ultrasonic extraction was 5.90 and 4.80 g/100 g of plant material, respectively. Based on FT-IR analysis, it was determined that the most represented components are free fatty acids and esters. Both fatty oils showed antioxidant activity as determined by DPPH test (EC_{50} value of 1.42 mg/ml and 4.75 mg/ml for fatty oil obtained by Soxhlet and ultrasonic extraction, respectively). The obtained results indicate possible application of grape seeds fatty oil in the food and pharmaceutical industries as a promising natural source of antioxidants.

Key words: Grape seeds, *Vitis vinifera* L., Fatty oil, Antioxidant activity.

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HYDRO-DISTILLATION OF CARAWAY SEEDS, CHARACTERIZATION AND MODELING

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Caraway seeds (Carum carvi L.) contain 3-6% essential oil widely used in a cosmetics and food industry. Carvone and limonene (about 95%) are dominant components in the oil.

The aim of this work was to analyze the dynamics of hydro-distillation of caraway seeds, characterization of obtained essential oil and mathematical modeling. The essential oils obtained from caraway seed were isolated by hydro-distillation using Unger-type of apparatus. Characterization of the essential oil was performed by gas chromatography and mass spectroscopy GC-MS, and 14 components were identified. The major constituents of the essential oil were limonene (31.7 %) and carvone (66.9 %). Kinetics of the hydro-distillation process was successfully fitted with empirical models based on exponential equations.

Key words: Caraway seeds, hydro-distillation, carvone, limonene, kinetics modeling.

ULTRASOUND-ASSISTED ALKALINE HYDROGEN PEROXIDE PRETREATMENT OF TOBACCO STALKS

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Annually, global tobacco production generates approximately 260 million stalks as post-harvest waste. Nowadays, the valorization of this biowaste type represents one of the most challenging issues. Due to the intact structure, pretreatment of the stalks is an important step before enzymatic hydrolysis that enables disrupting the recalcitrant lignocellulose and increases the accessibility of cellulose for enzymes.

The ultrasound-assisted alkaline hydrogen peroxide pretreatment of the tobacco stalks was performed at 60°C, 1:10 solid-liquid phase ratio, pH 11.5, frequency 40kHz and 500 W ultrasonic power. The hydrogen peroxide (H_2O_2) pH value to 11.5 was adjust by using sodium hydroxide (NaOH, 2 % *w/v*). The pretreatment time was changed from 30 to 90 min, while the H_2O_2 concentration varied from 0 to 5 % *w/v*. The solid residues that remained after vacuum filtration were rinsed to pH 7 with distilled water, followed by drying in an oven (105°C) to achieve constant weight. The contents of cellulose, hemicellulose and lignin were determined in the pretreated tobacco stalk samples by using the Chesson method.

The optimum pretreatment conditions of the tobacco stalks were reached for a time of 90 min with 3% *w/v* H_2O_2 (pH 11.5) at 60°C temperature and 1:10 solid-liquid phase ratio. The cellulose content was increased from 30.01% in the untreated to 37.98% in the treated sample, while the lignin and the hemicellulose decreased by 30% and 35% of the total content, respectively. Ultrasound-assisted alkaline hydrogen peroxide pretreatment effectively influence the tobacco stalk enzymatic digestibility for bioethanol production.

Key words: tobacco stalk, pretreatment, alkaline hydrogen peroxide, cellulose.

AUTHOR'S INDEX

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TITAN USJE

Цементарница УСЈЕ АД Скопје е производител на цемент и на други градежни материјали. Како членка на Групацијата ТИТАН, работи според најдобрите светски практики водејќи грижа за потребите на општеството и одржливиот развој преку одговорност и интегритет.

УСЈЕ е основана во 1955 година и денес е една од најголемите домашни компании со значаен придонес во развојот на земјата. Вработува повеќе од 250 вработени, а преку соработката со локални добавувачи и изведувачи овозможува создавање нови работни места. Компанијата управува со 3 рудници – рудник за лапорец Усје, рудник за варовник Говрлево и рудник за песок. Покрај производството на цемент, УСЈЕ поседува и погон за готов производ и агрегати, во кој произведува различни видови бетон. Со своите производи го снабдува домашниот пазар, како и пазарите во регионот (Косово, Албанија и Бугарија).

Цементарница УСЈЕ создава вредност преку трансформација на суровините во основниот градежен производ – цементот, служејќи ѝ на општествената потреба за квалитетно, безбедно и трајно домување и инфраструктура.

Цементарница УСЈЕ е посветена кон одржливост и има за цел да одговори на глобалните предизвици за одржливост во рамките на Целите за одржлив развој на Обединетите нации 2030.

Цементарница УСЈЕ е членка на Глобалниот договор на ОН од 2008 година.

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Our strategy

Our focus is creating products that aim to provide longer and better quality of life. All operational processes are within the frames of ethical working, working with the highest standards as well as in accordance the new needs of our customers, arising with the modern way of living. We tend to create individual approach for our users. We tend to create common wellbeing.

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We work today, for our common wellbeing!

MAKSTIL

The company Makstil AD Skopje was established in 1997 from the restructuration of the Government owned "Rudnici i Železarnica Skopje" (Mines and Iron & Steelworks Skopje) which started its operations in 1967.

In May 1996, the Government of the Republic of North Macedonia, as the majority stockholder, started seeking potential buyers for the facility as part of its privatization program and in March 1997, Duferco started its investment in Makstil, one of the 10 separate entities.

Since 2016, Duferco International Trading Holding has new shareholding structure as a result of the latest acquisition. DITH's trading and distribution network in Lugano is responsible for approximately 80% of the steel sales into the regional EU markets but also in other markets such as the USA, Canada, Middle East and North Africa.

Makstil's onsite marketing team in Skopje manages the direct domestic sales including: Turkey, Romania and Balkan countries.

At Makstil, we strive to be a successful safety oriented customer driven company.

By transforming scrap metal into high quality steel products, we protect the Environment and improve the Society where we operate, while maintaining excellent relations with the local community.

We achieve our goals by investing in technology, synergy of skills, knowledge and experience.

Everyone in Makstil is an important link in the chain, we are more than a team, we are a family.

To achieve mutual growth, we are moving forward together by adhering to our Values and high Standards.

BUČIM

Bucim DOO Radovish is the only operating cooper mine in North Macedonia. It is located in Radovish in southeastern North Macedonia. Bucim is an open pit mine which produces a concentrate containing copper and gold.Since 2005, the Bucim mine has been a part of Solway Investment Group, which has enabled Bucim to pursue a new path and secured the mine's long-term prospects.

Solway Investment Group has invested over €78 million in the Bucim mine. Bucim mine is a company that is socially and environmentally responsible**.**

Bucim is committed to making a positive impact in the communities in which we operate. We understand that the role of social responsibility extends to all aspects of all activities, including health, safety, environment and social. We integrate social factors into our decision-making process at all stages of our activities – from exploration and operations through closure and reclamation.

Since 2005, Bucim has made significant investments in the community and in support of environmental protection. Bucim, as a Solway group company, is continuing its efforts to make lasting contributions to society and will maintain the highest standards of integrity and transparency in its social and economic development programs.

Bucim is continually improving its environmental footprint. The company aims to identify, reduce and, if possible, completely eliminate any significant environmental impact caused by the mine's production activities. Bucim strives to ensure that all of its operations protect and improve the quality of the local land, air, and water.

VARDAR DOLOMIT

Вардар Доломит е Европски производител на синтер доломит, синтер доломитни опеки и маси. Лоцирана во град Гостивар во Р.С.Македонија и е во сопственост на групацијата ХАЗНЕДАР РЕФРАКТОРИС.
Имајќи директен пристап и контрола на главната суровина преку високо квалитетните рудници кои се во сопственост на компанијата, Вардар Доломит се наоѓа во стратешка предност во однос на неколкуте други производители на доломит во светот. Преработката суровини кои се добиваат од локални рудници представува високо ефикасен производен процес кој го минимизира влијанието врз околината и ја подобрува одржливоста на бизнисот.

Употребата на доломитот во индустријата за челик е рапидно зголемена во последните децении како резултат на нивната позитивна определба за производство на чист челик во чиста животна средина. Високиот степен на огноотпорност, инертноста кон челикот, одличните перформанси како и ниската цена го истакнуваат доломитот како разумен избор за производителите на челик во 21от век.

Со производен капацитет од над 60.000 тони годишно, Вардар Доломит е горд што ги снабдува своите потрошувачи со доломитни огноотпорни материјали од највисок квалитет, добиени по највисоки стандарди.

SANDA

SANDA is a company that has been established in the beginning for: designing, developing and producing women's tights and underwear, and now with 30 years of experience of the founders, who with courage, creativity and innovation are coping with the challenges of all those processes.

With our experience and flexibility in the textile industry, focused to thoroughly consider the needs of customers and suppliers, we are building strong ties with different companies in the region and in the EU, providing customers with a wide range of products supported by high quality standards.

РАКОМАК