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FACULTY OF TECHNOLOGY ZVORNIK

VIII INTERNATIONAL CONGRESS VIII

ENGINEERING, ENVIRONMENT AND MATERIALS IN PROCESS INDUSTRY

EEM2023

BOOK OF ABSTRACTS

JAHORINA
MARCH 20-23, 2023

REPUBLIC OF SRPSKA
BOSNIA AND HERZEGOVINA

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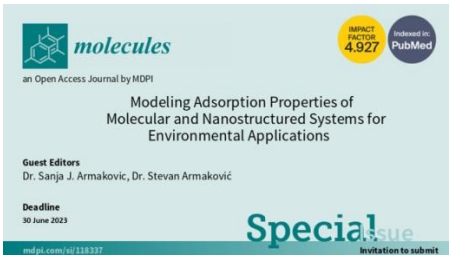

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CITY OF ZVORNIK

The municipality of Zvornik covers the surface area of 387 square kilometers in the north-eastern part of the Republic of Srpska in Bosnia and Herzegovina, an area with the population of 65 000. The town of Zvornik is situated on the eastern slopes of the mountain of Majevica, at 146 m above sea level. It is surrounded by the municipalities of Bratunac, Milići, Vlasenica (to the south), Šekovići, Osmaci, Sapna, Kalesija (to the west), Lopare, Ugljevik and Bijeljina (to the north). The river Drina on the east is a borderline with Republic of Serbia, i.e. the town of Loznica and the municipality of Zvornik.

The municipality of Zvornik is a crossroads of important roads to Sarajevo, Belgrade, Novi Sad, Bijeljina and Tuzla. Two bridges on the river Drina for road and rail traffic connect this area with the wider region, with Zvornik in the center, at equal distances from the three major cities – Belgrade, Novi Sad, and Sarajevo (approximately 160 km).

Fertile plains, a river rich in fish and suitable for navigation, mountains rich with forests, game and minerals have attracted people to settle the area since prehistoric times, and the earliest known inhabitants were the Scordisci, a Celtic tribe. The name Zvornik has been used since 1519, and the settlement was first mentioned in 1410 under the name of "Zvonik". Historic sites include the old town Đurđevgrad or the Zvornik fortress, the old town of Kušlat, The Andraš villa, the sheik's türbe, and the türbe of the poet Kaimija, necropolises and medieval tombstones called "stećci", the church St John the Baptist, and the local museum holds a collection of specimens of the cultural and historic heritage.

Natural resources include the hydro power potential of the river Drina as it runs through its territory for 50 km. Zvornik lake covers the surface area of 19 square kilometers (25 km in length and 1.3 km in width). It offers great possibilities for tourism, sports and recreation. The resources include the springs of mineral water from Kozluk and Vitinički Kiseljak, reserves of quartz sand, brick clay, structural stone, limestone and gravel. The municipality has 13 700 ha coverd by forest, 16 600 ha of arable land, and 10 500 farming housholds.

The municipality of Zvornik has 280 companies with 4500 employees, 800 businesses with 13000 employess, and around 40 institutions with approximately 2500 employees.

The most significant companies are AD Alumina factory Birač, Holding "Drinatrans" AD, AD "Zvornik putevi", AD "Vitinka", , DOO "Studen-prom", DOO "Obuća", AD "Vodovod i komunalije", DOO "Zo-Ži" , etc. Zvornik has founded a Business Zone covering a surface area of 10 ha with a cmplete infrastructure, suitable for investement.

Zvornik has 6 primary schools with 4200 pupils, two secondary schools with 18000 students, and one higher education institution - The Faculty of Technology. There is also Helath Institution and General Hospital important for the whole region.

German NGO *GTZ* has pronounced the municipality of Zvornik the best municipality in Bosnia and Herzegovina with respect to the treatment of the young, and the European Movement in Bosnia and Herzegovina has awarded Zvornik with "European open area" award.

ALUMINA DOO

Alumina d.o.o. was released into operation on 6th October 1978 and in the period 1984-1989 has paid a special attention to a development of products in the area of alumosilicate chemistry. During that period the company built five plants which also rely on the company's infrastructure and its raw material resources. The company is supplied with all the necessary raw materials, i.e. bauxite, quartz sand and energy from its immediate surroundings. Alumina d.o.o. is the only company in the Western Balkans and the southeastern Europe which uses the Bayer process to produce alumina and different types of hydrates from bauxite. Bauxite, supplied from the local mines, is advantageousin terms of micro impurity and the content of organic compounds.Alumina d.o.o.is also recognized by a symbiosis of several types of productions. Apart from hydrates and different types of alumina, the company also produces different types of zeolites, sodium silicates and liquid "water glass", and all products are in accordance with ISO and REACH Standards. The company's position in the eastern part of the Republic of Srpska and Bosnia and Herzegovina allows an easy access to the ports on the Adriatic sea and the river Danube, and, consequently, to the large number of countries to which it exports, such as Spain, France, Italy, Germany, Denmark, Netherland, Switzerland, Austria, Slovenia, Slovakia, Macedonia, Hungary, Czech Republic, Romania, Bulgaria, Poland, Ukraine, Russia, Belarus, Croatia, Serbia, Montenegro, Greece, Turkey, Israel, Saudi Arabia, Jordan, Tunis, Egypt, Sudan, Morocco, Algeria, Pakistan, India, China, USA, Columbia, Costa Rica.

ZEOCHEM DOO

Zeochem d.o.o. in Zvornik is a branch of a quality-oriented Swiss company with locations throughout the world. The company is a global market leader in complex industrial separation and purification processes. It makes molecular sieves that filter the impurities out of natural gas and bioethanol, and neutralize volatile organic compounds before they give off odors. The company creates the building blocks for OLEDs that conjure rasor-sharp images on smart phones and TVs. Zeochem supports the pharmaceuticals industry and the production of insulin and many other medicines, and by concentrating medical oxygen it improves many people's quality of life. The employees are committed to their customers worldwide and work with them to develop innovative solutions, products and processes. In recent years, the company has grown from a niche supplier to a global market leader in silicate chemistry. They produce in China, in the USA, in Bosnia and Herzegovina, and in Switzerland, and they are constantly expanding. Zeochem, a manufacturer of high-quality molecular sieves, chromatography gels and deuterated compounds, was established more than 200 years ago. In 1818, the Schnorf brothers lay the foundation stone for the CPH group to which Zeochem belongs when they opened a chemical factory in Switzerland. Swiss DNA is still a key factor in the company's success, shaping its identity and determining its actions. As a leading company in the silicate chemistry field, they set trends and create added value for their customers. The company's R&D teams focus on new product development, existing product improvement and understanding how their products are used in the customers' applications. Zeochem offers support for its customers as a trusted advisor and partner throughout the life of the products. Zeochem is committed to customer-focused innovation. The company continually develops new products with optimum performance for existing and new applications – offering better service lifetimes with more efficient materials.

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ELIXIR ZORKA - MINERAL FERTILIZERS DOO

Recognizing the importance of the production of mineral fertilizers, as well as the overall development potential of this branch of the chemical industry, Elixir Group privatized the factory Zorka Mineral fertilizers in the 2011. and incorporated it within its business system under the name Elixir Zorka. With an investment of 38.5 million euros, a new factory was built with the revitalization of all existing reservoirs for storing raw materials and associated infrastructure.

Elixir Zorka's production includes various formulations of complex mineral fertilizers of the highest quality, characterized by a high concentration of nutritive elements, uniform granulation and high water solubility in soil. These mineral fertilizers completely satisfy nutrient requirements of different crops, regardless of crop specificity, related production requirements and differences in soli quality. From the very beginning, Elixir Zorka has been devoting special attention to the needs of farmers, along with a deep knowledge of the market, and this is what distinguishes Elixir Zorka from the competition. Elixir Zorka's solutions and fertilizers are designed to improve plant nutrition, increase application efficiency and production profit, while on the other minimizing adverse environmental impacts.

As the leading producer of complex mineral fertilizers in Southeast Europe, Elixir Zorka produces and distributes over 350,000 tons of different formulations of NP, PK and NPK fertilizers annually.

Elixir Zorka is the absolute leader in the production and sales of complex fertilizers on the domestic market, with a market share of 50%. A large part of Elixir Zorka's products is distributed on the regional market and the strategic plan is to expand sales on the global market in the forthcoming period with aim to make brand Elixir Zorka globally recognizable by the top quality of our complex mineral fertilizers.

Elixir Zorka is focused on constant innovation and application of the latest technologies in the field of mineral fertilizers in order to provide high quality products to its customers. The next step towards this is the construction of a special plant for the production of special fertilizer formulations, which represents the innovation of the development team of expert Elixir Zorka. The key task of the development team is to create highly efficient solutions for farmers around the world, relying on deep knowledge of their requirements.

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ADVANCES IN THE SYNTHESIS OF NEW MATERIALS WITH AN UNDERSTANDING OF UNIT OPERATIONS IN METALLURGICAL ENGINEERING

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Abstract

The high demand for new materials, such as metals, oxides, and composites, raises the need for an advanced synthesis of different materials, which are crucial for technological applications. Different unit operations in metal engineering such as leaching, atomization, reduction in aqueous phase, crystallization, chemical precipitation, high pressure reduction in autoclave, and electrolysis, can be used to create controlled powder characteristics with specific properties for different application in industry. Advances in synthesis explores a wide range of materials and techniques used for powder metallurgy and the use of this technology across a variety of application areas such as medicine, catalysis and automotive industry. Aerosol synthesis from water solution of metallic salts different concentration with hydrogen reduction enables the formation of high entropy alloys such as AgPtPdCuNi and various magnetic powders. Preparation of metal particles such as gold, silver, copper by ultrasonic spray pyrolysis from water solution of metal salts with hydrogen reduction is especially challenging. Using aerosol synthesis, a single-step and multistep preparation process of different core-shall particles such ruthenium oxide/titanium oxide and nickel/yttrium oxide is possible through atomization, drying, shrinkage, solute precipitation, thermolysis, and sintering to form uniform spherical particles in nanosized and submicron range. Technical limitations of this technique, as well as a comparison with other synthesis methods (short residence time, difficulty in controlling morphology-porous or hollow particles, relatively low production rate and process of large volume of gas), will be partly considered in order to explain these problems. Especially, the newest results in the synthesis of nanosized particles by ultrasonic spray pyrolysis method and other methods will be reported in order to explain the role of used hydrogen to ensure decarbonization process. By addressing the complex problems faced in the synthesis procedures, the scaling–up of the aerosol droplet production and subsequent thermal decomposition will be presented via the synthesis of submicron silver from water solution of silver nitrate.

Key words*: materials, powders, synthesis, metallurgy, engineering, ultrasonic spray pyrolysis*

TAILORING ACTIVE SITES IN ZEOLITE-BASED CATALYSTS

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Abstract

Advances in catalysis towards new materials and energy production have fueled the development of modern society, particularly thanks to zeolites, which are microporous solid acids with versatile chemical composition. Replacement of mineral acids with acidic zeolites revolutionized the petrochemical industry in the second half of the twentieth century; the application of zeolites containing metal particles as catalysts for hydroisomerization, hydrocracking, and reforming processes has allowed the large-scale production of high-quality fuels and bulk chemicals. However, great progress achieved using zeolite catalysts for industrially relevant processes would have never been realized without accumulating a fundamental knowledge on the design of active sites, porosity, and crystal morphology of these materials. This contribution addresses recent developments and trends in tailoring the nature and local properties of active sites in zeolite-based catalysts, with a special focus on novel extra-large pore, layered, nanocrystalline, and hierarchical (mesoporous) zeolites with enhanced pore accessibility. The latest achievements in bottom-up and top-down approaches for isomorphous substitution in zeolites are discussed in a context of controlling over the type (Brønsted, Lewis, or both), amount, strength, and location of their acid sites. The incorporation of metal species of different sizes (increasing from single atoms to clusters and to nanoparticles) in zeolites allows expanding the set of reactions catalyzed by these materials. The main preparation strategies for designing metal–zeolite catalysts, especially those offering the control over the size of the metal species and their catalytic behaviour in emerging and industrially relevant sustainable catalytic processes are dealt with. Particular attention is paid to the stabilization of size-controlled small metal clusters and nanoparticles through their encapsulation in the voids of zeolite frameworks and to the dynamic behaviour of the metal species under reactive environments, which have important implications in catalysis. The need to use advanced in situ and operando spectroscopic tools in combination with theoretical modelling to reveal the precise nature and functioning of the active sites in working zeolites is emphasized.

Key words: *heterogeneous catalysis, zeolites, acidity, material engineering*

Acknowledgements: *This investigation is supported by the Ministry of Education, Youth and Sport of the Czech Republic through the ERC CZ project L2104.*

CHROMATOGRAPHIC PARAMETERS AS PREDICTORS OF PHENYLACETAMIDE DERIVATIVES' BIOLOGICAL ACTIVITY

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Abstract

Drug development is a complex, multidisciplinary, expensive and long-term process. Former approaches to drug discovery relied on the gradual synthesis of compounds with promising biological activity, while the greatest attention of contemporary scientists is focused on the important steps which precede the synthesis of new molecules. The rationalization of drug design in the early phase requires the quantification of the effect of structural changes on the relevant feature of the new entity, i.e. the selection of relevant molecular descriptors. Establishing valid and reliable mathematical models in QSAR (Quantitative Structure-Activity Relationship) studies essentially requires experimental and in silico determination of its significant physico-chemical, ADME properties (absorption, distribution, metabolism, excretion) and ecotoxicity. Lipophilicity is the most important molecular descriptor that is closely related to the compounds' bioavailability and thus crucial for defining its pharmacokinetic, pharmacodynamic and toxicological profile. In addition to the logarithm of the partition coefficient, logP, chromatographic parameters as reliable alternative measures of lipopohilicity are often used. Bearing in mind that a quarter of all drugs on the market contain amide groups, the subject of our research was phenylacetamides. Retention behavior of studied phenylacetamides was studied by using reversed phase thin-layer chromatography (RPTLC18F$_{254s}$) in the presence of different organic modifiers. The relationship between chromatographic parameters (R_M^0, m and C_0) of phenylacetamides on the one hand, and software obtained values of logarithm of the partition coefficient, logP, important pharmacokinetic predictors as well selected parameters of ecotoxicity on the other hand were examined by method of linear regression analysis. Obtained results indicate that the chromatographic parameters (R_M^0, m and C_0) of the tested diphenylacetamide derivatives, obtained in the applied modifiers, can be reliably used to evaluate their lipophilicity, ADME properties and ecotoxicity. Given that the data on phenylacetamides' lipophilicity and the existence of biological (pharmacological) activity were obtained in different ways, with the aim of their more detailed and comprehensive interpretation, the methods of multivariate analysis (Cluster Analysis and Principal Components Analysis) were applied. Based on all the obtained results, it was concluded that Cluster Analysis and Principal Components Analysis are adequate and sufficiently sensitive methods enabling information from a large number of analyzed data of heterogeneous origin on the dominant influence of various factors (substituent's nature and position, the influence of applied organic modifier) on the biological activity parameters of all tested phenylacetamide derivatives.

Key words: *phenylacetamides, lipophilicity, chromatographic parameters, bioactivity, multivariate methods*

SEAWEED IN FOOD: OPPORTUNITIES AND CHALLENGES

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Abstract

Seaweed is a highly nutritious food, containing a wide range of essential minerals, vitamins, and protein. It is traditionally consumed in Asia and is becoming increasingly popular in Europe and North America as a sustainable and functional food ingredient. The purpose of this review is to provide an overview of the opportunities and challenges associated with seaweed's use as a food ingredient. As a first step, seaweed is discussed in terms of its nutritional value, highlighting its high levels of minerals, vitamins, and protein. It is also emphasized that the nutritional value of seaweed can vary depending on the species and the method of preparation. Secondly, the functional properties of seaweed are discussed, including its bioactivity, thickening, emulsifying, and flavoring abilities. In addition, the review highlights the challenges associated with seaweed as a food ingredient, including the lack of standardization in the quality of seaweed used in food products, the insufficient knowledge about the nutritional value of different seaweed species, the unique flavor and texture of seaweed, as well as safety concerns regarding heavy metals and other contaminants. Research gaps in seaweed applications in food are also discussed, including the need for more research on the cultivation, processing, and nutritional properties of seaweed, as well as the need for research on consumer acceptance of seaweed-based food products. A discussion of EU policies on promoting seaweed as food is also included. In conclusion, seaweed has great potential as a food ingredient due to its high nutritional value and functional properties. However, there are several challenges that need to be addressed to fully utilize its potential, such as standardizing the quality of seaweed, research on nutritional value and functional properties, improving scalability, and ensuring safety. Further research is needed to fully understand the potential of seaweed as a sustainable and functional food ingredient.

Key words: *Seaweed, Nutritional value, Functional properties, Food ingredient, Research gaps*

PHYSICAL FOUNDATIONS OF NON-EQUILIBRIUM PLASMAS AS THE BASIS FOR TECHNOLOGIES RANGING FROM NANOELECTRONICS TO PLASMA MEDICINE AND PLASMA APPLICATIONS IN AGRICULTURE

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Abstract

In the domain of plasmas there are numerous distinctive groupings according to the conditions and most importantly physical properties. The most widely used separation is in the low temperature (cold) and thermal plasmas which matches very well the grouping to the non-equilibrium and equilibrium plasmas. In the past three decades non-equilibrium (low temperature) plasmas have opened numerous avenues for applications following the major successes of plasma processing in nano-electronics and treatment of materials. In this review we shall try to explain some of the essential physical processes and phenomenology that makes non-equilibrium plasma unique in that respect. First, one may observe dramatic changes of the energy distribution functions and spatial profiles during the breakdown and afterglow. Understanding those processes that are essentially equilibrations of the initial or boundary properties one may tailor make the desired distribution functions suited for specific applications. Failure to relax certain properties in sync with other properties of the plasma will lead to the so called 'kinetic phenomena' that may be linked with and used to optimise certain applications. At low pressures one may take advantage of the large mean free paths and of complete separation of energy distributions of electrons, thermal ions and gas molecules. Sheaths close to electrodes may provide high energy heavy particles that can be used for etching, erosion and cleaning in addition to or in synergism with the reactive species at thermal energies. We shall describe the physical underpinning of the reactive ion beam etching that was the fuel of the Moore law defined developments in nano-electronics. Furthermore we shall explain how charging of dielectrics introduced plasma induced damage that could be avoided by reactive fast neutral beam etching that opened the way for resolutions of well below 30 nm. One could consider taking the materials processing to atmospheric pressures, but limitations dictated by the plasmas at high pressures usually outweigh the advantages of not having to employ vacuum systems. However, if one wants to deal with organic materials and in particular with living organisms, it is necessary to operate at atmospheric pressures. Under those conditions non-equilibrium is difficult to achieve but recently a wide range of sources have been developed that made it possible to consider fields such as plasma medicine and plasma agriculture. Strategies for achieving the desired degree of non-equilibrium at such pressures and for the relevant gas mixtures will be connected to the basic knowledge of the particle swarms and related kinetic phenomena. Nevertheless physics under such conditions will require more consideration of the space charge development. We shall show some examples of how our recently improved understanding of non-equilibrium plasmas may be used to tune and even develop specific targeted atmospheric pressure plasma applications.

Key words: *non-equilibrium, kinetic phenomena, etching, plasma agriculture, plasma medicine.*

Acknowledgements: *Author is grateful to the SANU project F155 for partial funding.*

SUSTAINABLE WASTE AND BIOWASTE MANAGEMENT

M. Loizidou[1], D. Malamis[1], K. Moustakas[1], E.M. Barampouti[1], S. Mai[1], J. Novakovic[1]

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Abstract

Sustainable waste and biowaste management are a key element of the bioeconomy. It involves the collection, sorting, recycling and valorizing of biowaste such as food waste, paper, and yard waste. To create a circular economy, biowaste should be reused, recycled, or composted instead of being sent to landfills or incinerators. This reduces the amount of new resources used to create materials and helps reduce greenhouse gas emissions. Additionally, by using biowaste to create energy or nutrients for agriculture, it creates economic opportunities in rural areas. Circular economy and bioeconomy are the policies adopted as a response to the unsustainable use of natural resources. It is argued that implementing these concepts in tandem, through a systemic approach including design principles and process integration, would ensure resource efficiency and sustainability. EU waste policy aims to protect the environment and human health targeting improved waste management, stimulating innovation in recycling, and limiting landfilling. The Waste Framework Directive is the EU's legal framework for treating and managing waste and is based on three primary principles: Prevention, Polluter-pays principle, and Extended producer responsibility. The circular economy makes both environmental and business sense. In the circular economy, growth no longer requires an increasing extraction and consumption of resources, energy, water and primary raw materials. There is less waste, and products and resources maintain their value in the economy for as long as possible. The circular economy needs more than traditional R&D or a piecemeal approach to technologies: it needs changes in entire systems and joint efforts by researchers, technology centres, industry and SMEs, the primary sector, entrepreneurs, users, governments and civil society. It needs enabling regulatory frameworks, and additional public and private investments. Thus, waste should be treated as a valuable resource in the circular economy model. Biorefineries could stand as a strong link between circular economy and bioeconomy presenting common objectives and areas of intervention. A biorefinery produces a spectrum of marketable products to maximize its economic sustainability and aims to "zero waste. The valorisation of biowaste under the circular bioeconomy context is of high priority. It is a feedstock with a high fluctuation in its composition, but in all cases, it contains valuable components that could be transformed into added-value products. The development of integrated biorefineries using biowaste as substrate presents a promising resource-efficient and sustainable alternative through the synergistic action of the production sector and waste management in a circular bioeconomy. However, challenges in upscaling exist due to the complexity of the entire value chain. To this end, the Unit of Environmental Science and Technology, School of Chemical Engineering, National Technical University of Athens, Greece has demonstrated a wide range of technological approaches at different TRLs in line with the circular economy concept. The experience and the lessons learnt from the demonstration sites could pave the way to the sustainable waste and biowaste management.

Key words:*Waste Management, Bioeconomy, Biorefinery, Circular Economy, Legal Framework.*

LAVANDIN (*Lavandula x intermedia*) ESSENTIAL OIL - ANTIMICROBIAL POTENTIAL AND OIL MICROENCAPSULATION BY FREEZE DRYING

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Abstract

Lavender essential oils possess many different beneficial biological properties, including antioxidant activity and inhibitory effect on many types of foodborne, human and environmental microorganisms. Possessing high volatility, poor water-solubility, thermal and chemical instability, essential oils are a suitable candidate for microencapsulation, enabling their applicability as natural preservatives in various industrial sectors. The aim of this study was to investigate the difference in lavandin (Lavandula x intermedia) essential oils chemical composition, as well as microbiological and antifungal activities of oils obtained from plants material grown in 2020 and 2021 at territory of Serbia. Lavandin essential oil was obtained by steam distillation. Chemical composition of essential oils was analyzed by GC/MS. Obtained oil was encapsulated by freeze drying, where maltodextrin (MD) and whey protein concentrate (WPC) were tested as wall materials. Emulsification procedure involved the addition of essential oil into wall material solution by homogenization at 10000 rpm during 5 min. The core/wall material ratio was 1:4 (w/w). Total oil content and surface oil content in the microcapsules, oil retention efficiency (RE), encapsulation efficiency (EE), moisture, hygroscopicity and TGA analysis of microcapsules were determined. The results indicate that investigated lavandin essential oils possess excellent antimicrobial activities against several investigated bacterial strains (S.aureus, B. cereus, E. coli, E. faecalis, S. enterica and K. pneumoniae) and fungi that are significant producers of mycotoxins (A. flavus, F. graminearum, Penicillium sp.). Microencapsulation by freeze drying did not shown promising results when MD have been used as a carrier, where less than 1% of oil was entrapped into microcapsules. However, addition of WPC in a mixture with MD (1:1) allowed production of microcapsules with RE of 53.87 ± 1.89 %, EE of 68.47 ± 1.05 %, moisture of 2.32 ± 0.06 % and hygroscopicity of 10.64 ± 0.15 %. TGA curves indicate that encapsulation of lavandin essential oil give the possibility of thermal protection of this high volatile oil.

Key words: *lavandin essential oil, antimicrobial effect, microencapsulation, freeze drying*

Acknowledgements: This research study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project No. 451-03-68/2022-14/200134).

HIGH MOLECULAR WEIGHT CHITOSAN FOR FLOCCULATION OF *Bacillus* sp. FROM FERMENTATION BROTH

Selena Dmitrović, Ivana Pajčin, Vanja Vlajkov, Jovana Grahovac, Aleksandar Jokić, Nataša Lukić

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Abstract

For cultivation and downstream processing of microbial broth, cost-effective and environmentally friendly technologies are needed in order to produce biomass on a wide scale for low-value applications, such as agricultural production. Cultivation broth based on industrial wastes was developed for biomass production by a Bacillus sp. strain BioSol021 that showed a great potential as biocontrol agent. The industrial wastes used as cultivation medium were whey obtained from cheese production, flotation wastewater from wine industry and wastewater from fruit juice production. Cheese whey wastewater is rich in nutrients, organic and inorganic materials and its composition is highly variable. Flotation wastewater from wine industry is of great concern due to its complex composition, it contains various organic and inorganic contaminants that are slowly biodegradable. Wastewater from fruit juice production contain high concentrations of organics due to usage of fruits or sugar. Hence, sustrainable valorization of these wastes requires utilization of various methods including biological methods such as microbial treatment. Harvesting bacterial biomass represents a significant challenge. Among different harvesting methods such as centrifugation, filtration, flotation, sedimentation, flocculation is considered as one of the most promising and cost-effective harvesting methods. The primary application of flocculating agents is to aid in solid-liquid separations, which are generally classified into two types: settling and filtration. Flocculation causes biomass cell clumps to form larger clumps that are easier to filter and/or settle more quickly to facilitate harvesting. The use of chemical flocculants can cause adverse effects on the environment and threaten human health. To overcome these problems, natural flocculants such as chitosan have been used for harvesting. Bio-based flocculation offers great potential as an environmentally friendly and potentially cost-effective approach and they are becoming potential alternatives to inorganic and synthetic organic flocculants. The aim of this work is to evaluate biomass harvesting by flocculation from different types of industrial wastes used for biomass production. Experiments were performed to determine the optimum flocculant dose, at pH value 5.0, using high molecular weight chitosan (≥90% deacetylated, molecular mass 600,000-800,000 Da). It was found that high molecular weight chitosan could be applied as the flocculating agent for separation of Bacillus sp. biomass from different cultivation broths. The highest degree of flocculation efficiency of whey obtained from cheese production broth (95.98%) was achieved when chitosan concentration was 120mg/L. The highest degree of flocculation efficiency of flotation wastewater from wine industry (99.47%) and wastewater from fruit juice production (98.17%) broths was achieved when chitosan concentrations were 600mg/L and 672.5 mg/L respectively.

***Key words**: chitosan, flocculation, fermentation broth, Bacillus sp.*

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GLYCEROL AS GREEN SOLVENT FOR ENCAPSULATION OF ESSENTIAL OIL INTO BETA CYCLODEXTRIN

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Abstract

The purpose of this study is to investigate the effect of essential oil medium on the inclusion complex of L. stoechas EO in β-cyclodextrin, as well as to examine the impact of the encapsulating action on the adulticidal activity. In line with this, L. stoechas EO was hydrodistilled and determined through GC-MS. Furthermore, the optimization of EO medium was conducted using a binary mixture design of ethanol and glycerol as green emulsifier solvent. Fourier transform infrared spectroscopy, scanning electron microscopy, X-ray powder diffraction and thermogravimetric analysis were used to verify the establishment of the IC. The insecticidal effect of the created formulation was evaluated against C. pipiens female mosquitoes. The optimum ethanol: glycerol ratio was 0.73: 0.27, corresponding to 58.86% of encapsulation efficiency. The fumigant test showed that, after 24 h of exposure, L. stoechas EO exerted only 24.56 ± 1.04%, while the encapsulated oil killed 57.89% of the adult population. At the highest dose (312.5 µl/L), the encapsulated oil provided the most significant effect on adults (100% mortality after 54 h) compared to non-encapsulated oil (100% mortality after 72 h). The encapsulated form of L. stoechas EO constitutes a promising alternative for the control of mosquitoes that are responsible for human diseases.

Keywords*: Lavandula stoechas, inclusion complex, β-cyclodextrin, mixture design, insecticidal activity, Culex pipiens.*

CHEMICAL COMPOSITION AND ANTIMICROBIAL ACTIVITY OF WILD CARROT (*Daucus carrota* L.) SEED ESSENTIAL OIL FROM SOUTHEASTERN SERBIA

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Abstract

Daucus carota L. ssp. carota, commonly known as wild carrot, is a very commonly used nutritional and medicinal plant from the family of Umbelliferae. Wild carrot is a popular medicinal plant with various pharmacological activities mentioned in traditional medicine and modern phytotherapy, including antioxidant, analgesic, anti-inflammatory, antimicrobial, antifungal, diuretic, lithontripic, emmenagogue, intra-occular hypotensive, gastroprotective, hepatoprotective, aphrodistic, nephroprotective, antispasmodic, anticancer, antiestrogenic, cardioprotective, and wound healing activities. Seeds from wild carrots have been used for medicinal purposes since ancient times. Today the essential/fatty? oil of its seeds has been proved to possess antinociceptive, antiinflammatory, hypoglycaemic, antidiabetic, antioxidative and anticancer activity. Carrot seed essential oil is widely used as a flavoring agent in food products and perfumery since it blends very well in all kinds of perfumes. The aim of this study was to investigate the chemical composition, and antimicrobial activity of the wild carrot seed essential oil (grown in the village of Badince, Leskovac, Serbia). The oil was obtained by Clevenger-type hydrodistillation with hydromodule 1:10 m/V. The qualitative and quantitative composition of essential oil was determined by GC/MS and GC/FID analyses. The antimicrobial activity of essential oil was investigated by the disc-diffusion method in terms of their possible application as natural antimicrobial agent on the following microorganisms: Escherichia coli (ATCC 25922), Pseudomonas aeruginosa (ATCC 27853), Proteus vulgaris (ATCC 8427), Staphylococcus aureus (ATCC 25923), Bacillus subtilis (ATCC 6633), and Candida albicans (ATCC 2091). The GC/MS analysis of essential oil resulted in the identification of 49 compounds (99.3% of the total oil composition). Oxygenated monoterpenes (with geranyl acetate (55.1%) as their representative) were the main components found (60.5%), followed by oxygenated sesquiterpenes (17.9%) and sesquiterpene hydrocarbons (13.3%). The wild carrot seed essential oil showed antifungal activity against Candida albicans (13.0 mm), and antimicrobial activity against Bacillus subtilis (13.0 mm), and Escherichia coli (13.5 mm), while it had no effect on Pseudomonas aeruginosa, Proteus vulgaris, and Staphylococcus aureus. The obtained results regarding the antimicrobial activity of wild carrot seed essential oil indicate its possible application in the food and pharmaceutical industries as a safer alternative to synthetic additives.

Key words: *Essential oil, Wild carrot, Daucus carrota L., GC/MS analysis, Antimicrobial activity.*

Acknowledgements: This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia under the Program of financing scientific research work, number 451-03-68/2022-14/200133. Aleksandra Milenković is a Scholar of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

ANTIOXIDANT ACTIVITY OF WILD CARROT (*Daucus carota* L.) FATTY OIL FROM SOUTHEASTERN SERBIA

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Abstract

Herbs have been used since ancient times as medicines for the treatment of a wide range of diseases. In recent years, we have seen return to traditional folk medicine and the use of extracts of natural origin as medicines or health-promoting agents, which has resulted in increased interest in substances with a specific biological activity. Today, modern methods enable scientists to approve medicinal plants for healing many disorders. The wild carrot, Daucus carota L., belongs to the family Apiaceae (Umbelliferae) and is sometimes referred to as the subspecies carota. Its flower umbels are edible and usually French- fried, and its seed oil, which is commercially available, is used to flavor beverages and food products. Available literature on the therapeutic effects of wild carrot showed that the plant possessed antilithic, diuretic, antibacterial, and antifungal activities. Wild carrot seeds show antinociceptive, anti-inflammatory, antioxidative, and anticancer effects. Extracts of wild carrot umbels exhibited anti-inflammatory, anti-ulcer, anti-cancer, and antioxidant activities. The aim of this study was to determine the antioxidant activity of fatty oil isolated from wild carrot seeds from Southeastern Serbia. The fatty oil was isolated by Soxhlet extraction using hexane as extragens. The solvomodule was 1:10 m/V. Antioxidant potential was estimated by using the DPPH and ABTS assays. The qualitative composition of fatty oil was determined by HPLC and FT-IR analysis. The yield of fatty oil obtained was 1.95 g/100 g of plant material. Based on HPLC and FT-IR analysis, it was determined that the most represented components are free fatty acids and triglycerides. According to the results obtained, fatty oil showed antioxidant activity as determined by DPPH (EC_{50} value of 11.64 mg/ml) and ABTS tests (EC_{50} value of 22.65 mg/ml). However, determination of the chemical composition of wild carrot fatty oil will be the subject of our further studies. The obtained results regarding the antioxidant activity of wild carrot fatty oil indicate its possible application in the food and pharmaceutical industries as a promising natural source of antioxidants.

Key words: *wild carrot, Daucus carota L., fatty oil, antioxidant activity.*

Acknowledgements: This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia under the Program of financing scientific research work, number 451-03-68/2022-14/200133. Aleksandra Milenković is a Scholar of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

ANTIBACTERIAL ACTIVITY OF *Allium sativum* AND *Allium ursinum* ON SELECTED FOODBORNE PATHOGENS

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Abstract

Foodborne pathogens are a major health problem around the world and reason for use of food preservatives. Common use of chemicals as food preservatives increase consumer demand for minimal processed and clean label products. In recent years natural preservatives are gaining importance and an attention of the scientific public. In this study, antibacterial properties of domestic garlic (Allium sativum) and wild garlic (Allium ursinum) were examined against Gram positive strains (Staphylococcus aureus) and Gram negative strains (Salmonella spp.). Herbal extracts of garlic were purchased at the pharmacy, and wild onion tincture was prepared in the traditional way in home conditions. Antibacterial activity is determined by diffusion method. Based on the results of antibacterial tests, the inhibition zones for Allium ursinum were from 19.66 to 24.33 mm according to Gram positive strains, and according to Gram negative strains from 17.33 to 25.66mm. The inhibition zones for Allium sativum were from 10.33 to 25.00 mm for Gram positive strains and from 19.66 to 26.33mm for Gram negative strains. The obtained results confirmed that Allium sativum oil and tincture of Allium ursinum have satisfactory antibacterial activity agains the tested bacterial strains.

***Key words**: Allium sativum, Allium ursinum, antibacterial activity, salmonella, staphylococcus*

ISOLATION OF COAGULASE-NEGATIVE STAPHYLOCOCCUS FROM SAMPLES OF RAW MILK AND THEIR RESISTANCE TO ANTIMICROBIAL DRUGS

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Abstract

Antimicrobial resistance is one of the most significant problems in veterinary public health, especially when it comes to pathogenic microorganisms. Coagulase-negative staphylococci are opportunistic pathogens, animal commensals and an important microorganisms in the production of food of animal origin. Finding coagulase-negative staphylococci isolated from the raw milk as a strains antimicrobial resistant could be a sign of a health risk as well as information about over use antimicrobial drugs. The resistance of 10 strains coagulase-negative staphylococci isolated from the raw milk samples on 14 antimicrobial drugs (amikacin, amoxicillin, ampicillin, penicillin, ceftriaxone, cefalexin, cefuroxin, cefazolin, nalidixinic acid, gentamicin, lincomycin, tetracycline, sulfamethoxazole and imipenem) was examined using the disc-diffusion method. Obtained results show that a resistance to imipenem and cefuroxime was exhibited by all isolates (100%), while 90% of the isolates were resistant to sulfamethoxazole. Resistant on penicillin, nalidixinic acid and lincomycin were 80% isolates, and on ampicillin 70% isolates. All isolates were multiple resistant to five or more antimicrobial drugs and indicated a history of antimicrobial drugs use.

***Key words**: antimicrobial resistance, milk, staphylococci*

BACTERICIDAL EFFECTIVENESS OF ACTIVE CHLORINE SOLUTION WITH ESSENTIAL OILS

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Abstract

Insufficient hygiene of food contact surfaces often leads to food contamination with bacteria that cause foodborne diseases in humans, which is a growing public health problem and causes large economic losses, despite modern improvements in food production and preservation techniques. The use of natural substances with antimicrobial activity, such as essential oils, is an environmentally friendly and effective way to control the presence of potentially pathogenic bacteria. These agents are increasingly used in combination with conventional antimicrobial agents. Therefore, the aim of this study was to examine the antimicrobial activity of essential oils namely Lavandula officinalis (lavender), Melaleuca alternifolia (tea tree), Menthae piperitae (mint) and Rosmarinus officinalis (rosemary), and active chlorine solution (0.1%) against two gram-positive bacteria Bacillus cereus ATCC 11778 and Staphylococcus epidermidis ATCC 12228, and two gram-negative bacteria Pseudomonas aeruginosa ATCC 10145 and Salmonella Typhimurium ATCC 14028, as well as to evaluate the antimicrobial activity of essential oils and active chlorine solution (0.1%) (Aqualor H1000, Sigma d.o.o., Crvenka) mixed in different combination (FIC) in order to detect synergistic or antagonistic effects and discuss these effects (FICI, FIC index) on the basis of an improved checkerboard technique. The results showed a synergistic and additive effect for most combinations of active chlorine solution and essential oils. While with the reference strain P. aeruginosa ATCC 10145, an indifferent effect was observed in the combination of active chlorine solution with essential oils of mint and rosemary. The effectiveness of the solution of active chlorine with essential oils was determined using the quantitative suspension test according to the DGHM method. The results indicated that the maximum germicidal effect of the solution was achieved after exposure for 5 minutes for all tested bacteria. The lowest degree of reduction was recorded against B. cereus ATCC 11778 and S. Typhimurium ATCC 14028 at the shortest exposure time of 1 minute, while a stronger effect was recorded against S. epidermidis ATCC 12228 and P. aeruginosa ATCC 10145. Taking into account that there has been an increased interest in the use of natural antimicrobial agents in recent years, the application of a combination of active chlorine with essential oils represents a significant strategy in the control of pathogenic bacteria.

Key words: *bactericidal efficiency, active chlorine, essential oils.*

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ESSENTIAL OILS AS ANTIMICROBIAL AGENTS AGAINST BACTERIA *Listeria monocytogenes*

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Abstract

Listeria monocytogenes is an important gram-positive foodborne pathogen which can cause the serious illness, listeriosis, which leads to a 30% rate of mortality among patients. This bacteria is often linked to ready-to-eat food because it is able to grow at refrigeration temperatures and many outbreaks are associated with the consumption of these products. With this in mind, the application of essential oils (EOs) to food products is a suitable strategy to control pathogens and to extend their shelf life by reducing microbial levels. The main objective of the present study was performed in order to evaluate the efficacy of EOs against L. monocytogenes. The EOs used in this study were caraway (Carum carvi), cinnamon (Cinnamomum zeylanicum), dill (Anethum graveolens), clove (Syzygium aromaticum), mentha (Menthae piperitae aetheroleum), red thyme (Thymus vulgaris), rosemary (Rosmarinus officinalis), common sage (Salvia officinalis), clary sage (Salvia sclarea) and summer savory (Satureja hortensis). The broth microdilution method was used to determine the minimum inhibitory concentrations (MICs) of plant essential oils (EOs). According to the MIC values, all essential oils were effective in the inhibition of L. monocytogenes strains, with MICs varying from 256 μg/ml to 4096 μg/ml. The results showed that cinnamon EO had the highest antimicrobial activity, while dill and mentha were the least effective against the L. monocytogenes strains. Hence, these findings open up new perspectives on the application of EOs as biopreservatives against food-borne pathogens.

Key words: *Listeria monocytogenes, antimicrobial activity, essential oils.*

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COMPARISON OF THE PERFORMANCE OF FT-RAMAN AND NIR FOR CHEMICAL SCREENINGOF ACACIA PODS

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Abstract

Invasive species, namely Acacia spp., have become a major problem for natural ecosystems due to land fragmentation and loss of biodiversity.Acacia spp is one of the most aggressive invasive species in Portuguese forests. Pods of four Acacia species (A. dealbata, A. retinodes, A. longifolia and A. pycnantha) were evaluated concerning the extraction of phenol and flavonoid compounds to identify potential industrial uses. The pods were lyophilized and frozen at -80 °C until analysis. The extraction was performed in 10 g of lyophilized Acacia samples, with 100 mL of 99% ethanol on an orbital plate shaker for 24 h with constant stirring. After filtration, the extracts were centrifuged (4000x g, 20 min) and concentrated using a rotary evaporation system (40 °C). The chemical characterization and quantification were performed by a high-performance liquid chromatography-diode array detector (HPLC/DAD) and liquid chromatography-electrospray ionization high-resolution tandem mass spectrometry (LC-ESI-HRMS/MS). The lyophilized material was analyzed by Fourier Transform Raman Spectroscopy (FT-RAMAN) and Near-infrared spectroscopy (NIR). In NIR, the samples were measured in reflectance mode with a spectral resolution of 16 cm^{-1} and 32 scans in the wavenumber range of 12000 to 4000 cm^{-1}. For the analyses in FT-RAMAN, a quartz cell of 5 mm of optic space was used with a spectral resolution of 32 cm^{-1} and 64 scans in the wavenumber range of 4000 to 200 cm^{-1}. The identified compounds are from various organic families, including simple phenolics, hydroxybenzoic aldehydes, hydroxybenzoic acids, hydroxycinnamic aldehydes, hydroxycinnamic acids, furans, flavonols, flavonoids and flavones. Principal component analyses were conducted using the analytical data and spectral information collected with FT-RAMAN and NIR. The results demonstrated that vibrational spectroscopy could easily discriminate the differentiation shown by analytical methods. Acacia pods appear to have a unique and distinct profile of compounds with various potential applications.

Key words: *Acacia, Pods, Chromatographic analysis, FT-RAMAN, NIR*

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DETERMINATION OF GLIADIN AND GLUTENIN PROTEINS FROM BISCUIT BY RP-HPLC AND FTIR METHOD AFTER TREATMENT WITH COLD ATMOSPHERIC PLASMA

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Abstract

Biscuit is a popular food product. The main ingredient is wheat flour. In addition to wheat flour, sugar and fat are also used for the production of biscuits. The most important protein in wheat flour is gluten. Gluten is a protein that consists of two fractions. These are gliadins and glutenins. There are numerous methods for the separation and quantification of gluten proteins, but the most commonly used is reversed-phase high-pressure liquid chromatography (RP-HPLC). Fourier transform infrared spectroscopy (FTIR) is a method that is often used in the food industry today. This method can quickly determine the presence of gluten in a food product. Taking into account that the number of people who suffer from celiac disease in the world is increasing every day, the aim of this work was to determine gliadins and glutenins from biscuit samples after treatment with cold atmospheric plasma (CAP). The samples were treated in solid and liquid state and compared to untreated samples. After the treatment, the changes were monitored by RP-HPLC chromatography and the FTIR method. Gliadin and glutenin separation was performed on an HPLC apparatus (Agilent Technologies 1260 Infinity). The proteins were separated and the total amount of proteins, the amount of proteins within each fraction, and their relative concentration were determined. Recording of IR spectra was performed on an Agilent Cary 630 FTIR instrument, using the attenuated total reflection (ATR) method in the range from 4000 to 650 cm^{-1}. After the treatment of samples with cold atmospheric plasma (CAP), and then the analysis of gliadin by RP-HPLC chromatography, the total amount of protein was reduced, during the treatment of the extracts, while the total amount was increased during the treatment of the samples in the solid state, compared to the untreated sample. These changes were observed when recording the absorbance at 210 and 280 nm. By recording the IR spectra of gliadin and glutenin, no changes were observed. For this reason, it is better to use the RP-HPLC chromatography method than FTIR spectroscopy.

Key words: *gluten proteins, biscuit, RP-HPLC chromatography, FTIR.*

STUDY OF LIPOPHILICITY AND TOXICITY OF SELECTED *N, N*-DISUBSTITUTED CHLOROACETAMIDES USING LIQUID CHROMATOGRAPHY

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Abstract

The earliest stage in drug development involves screening hits, iterative medicinal chemistry, and optimizing hits to reduce potential drug side effects. Given that the passage of molecules through biological membranes, and thus its bioavailability, is determined by its lipophilic nature, in order to increase the affinity and selectivity of the hit, the first task is evaluation of its lipophilicity. Lipophilicity of novel derivatives of N,N-disubstituted chloroacetamides was determined computationally as well as experimentally by using reversed-phase thin-layer chromatography (RPTLC18F254s) in the presence of two protic (methanol and ethanol) and two aprotic organic modifiers (acetone and dioxane). It was found that the chromatographic behavior of the studied chloroacetamide derivatives depends to a greater extent on the nature of the substituent (number of carbon atoms) in the molecule, and less on the nature of the used organic modifiers. Chromatographic parameters, R_M^0 and m, of the chloroacetamides as assumed measures of their lipophilicity were correlated with the software obtained values of the standard measure of lipophilicity, logarithm of partition coefficient, logP, and selected parameters of toxicity, whereby valid mathematical models were obtained.

Key words: *N,N-disubstituted chloroacetamides, liquid chromatography, lipophilicity, toxicity*

INFLUENCE OF HUMIC AND FULVIC ACIDS ON STABILITY OF LOBO® AND ITS PROLONGED ACTIVITY IN ONION PRODUCTION

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Abstract

With increasing food demand, agriculture modernization, and pesticide marketing, the use of pesticides has risen tremendously in the last few decades. To answer the needs of humanity, the widespread use of pesticides is inevitable in agriculture. Various studies have revealed that the exposure of humans to high concentrations of residual pesticides in food and water leads to serious chronic effects. Using humic and fulvic acids (HFA) in the presence of pesticides is an effective way to enable prolonged action of pesticides and thus increase the food yield. This study investigated the influence of HumiBlack® (a compound based on HFA) on the stability and prolonged activity of Lobo® pesticide (active component: imidacloprid, distributor: Agromarket, Serbia) in the case of onion growing. Direct photolysis of Lobo's® active component was performed in ultrapure and groundwater (used for onion irrigation) using a sun simulator. After 120 min, 44.25% of imidacloprid was degraded by direct photolysis using the sun simulator. In groundwater, 37.56% of imidacloprid was degraded, indicating that some ions present in groundwater (hydrogen carbonates, calcium, magnesium, chloride, sodium, and potassium) contributed to imidacloprid's stability. Adding HumiBlack® in both ultrapure and groundwater made imidacloprid completely stable during 120 min irradiation. In addition, extensive field experiments showed that the combination of HumiBlack® and Lobo® produced a series of positive effects on the yield. Namely, the aboveground yield mass was significantly higher; the height and diameter of the bulbs from the same treatments increased by 10.76% and 8.75%, respectively, while the hardness of the bulbs increased by 2.85%. Results obtained by our laboratory and field experiments indicate that a significantly better yield quality can be attributed to the stabilization effect of HumiBlack® on Lobo®, which prolongs the interaction of this pesticide with the plants. This is considered an ecological and economical method for increasing food yield in today's world with growing food demand.

Key words: *Imidacloprid, Pesticide, Onion, HumiBlack, Sun simulator, Photolysis*

KINETIC INVESTIGATION OF THE STABILITY OF HYPERFORIN FROM *HYPERICUM PERFORATUM* L. UNDER UV-B IRRADIATION

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Abstract

Hyperforin is the major of the two acylphloroglucinols present in Hypericum perforatum. Numerous activities has been detected, antibacterial, antidepressant, anti-inflammatory and antitumor activity. Hyperforin stability is influenced by higher temperatures, light and oxygen. Its propensity for oxidative degradation as well as Hypericum perforatum L. commercial products poses serious problems for standardization and can also dramatically affect the final pharmacological activity. The kinetic investigation under UVB irradiation of hyperforin rich methanol extract has been investigated. The extract used in this study is obtained by the maceration process of 2 g of dried and well-ground plant material (Hypericum perforatum L.) in 10 ml of methanol. Continuous irradiations of the samples were performed in a cylindrical photochemical reactor "Rayonnet", with 8 symmetrically placed lamps with emission maxima at 300 nm. The total measured energy flux received by the sample is 12 W/m^2. Liquid chromatography in combination with mass spectrometry has been used in order to identify UVB induced changes in hyperforin content in Hypericum perforatum L. extract. Based on the obtained results during the irradiation time of 0-30 minutes, it can be concluded that hyperforin is very unstable. After 5 minutes of irradiation, a degradation of 44.52% occurs; after 30 minutes of exposure to UV-B radiation, 99.97% of hyperforin is degraded. Also, it was shown that in terms of stability, the degradation of hyperforin follows 1^{st}-order kinetics. The corresponding bleaching (degradation) rate constant of hyperforin is 0.06 min^{-1}.

Key words: *Hypericum perforatum L., hyperforin, irradiation, kinetic.*

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ANALYSIS OF ANTIMICROBIAL ACTIVITY OF HYPERFORIN (*HYPERICUM PERFORATUM* L.) EXTRACTS

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Abstract

Hypericum perforatum L. has pharmacological functions including antidepressant, antioxidant, antifungal, analgesic, anti-inflammatory, cytotoxic, and antidiabetic activities. Hyperforin is one of the main bioactive ingredients of Hypericum perforatum L. with an effect on a large number of different neurotransmitters and microorganisms as well. The way and extraction conditions affect the final hyperforin content and therefor its activity. The aim of this work was to isolate hyperforin rich extract (HP) that can find further application in final products and to examine its antimicrobial activity. Extraction was carried out by conventional maceration and sonication method with methanol. The antimicrobial activity was determined using a disc-diffusion method. A disc-diffusion method was used in the antimicrobial activity investigation on the following pathogenic microorganisms: Candida albicans, Proteus vulgaris, Pseudomonas aeruginosa, Bacillus subtilis, Staphylococcus aureus, Escherichia coli, and Listeria monocytogenes. Extracts obtained by maceration and sonication methods were 99 and 82 mg/g d.w., respectively. The obtained HP extracts show no activity on: Pseudomonas aeruginosa, Escherichia coli, and Candida albicans. The samples of HP extracts showed antimicrobial activity against Proteus vulgaris, Staphylococcus aureus, Bacillus subtilis, and Listeria monocytogenes. The results indicate that HP extract is a good antimicrobial agent with potential application in the food and pharmaceutical industries as a safer alternative to synthetic antimicrobial agents.

Key words*: Hypericum perforatum L., Antimicrobial, extracts.*

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SYNTHESIS, STRUCTURE CHARACTERIZATION AND SOLVATOCHROMISM OF SOME ARYL AZO PYRIDONE DYES

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Abstract

Aryl azo pyridone dyes belong to a very important class of organic compounds. World annual production of synthetic dyes is over 60 % based on the azo derivatives. They are mostly used as coloring agents for textiles, paper, leather, rubber, polymer, and many other materials. With the development of high technology, these structures also found their application as components of lasers and nonlinear optical systems, LCD (liquid crystal display) screens, and thermal printers. Lately, increasing attention has been directed to the biological activity of azo compounds. It has been proven that they have anti-tumor, anti-inflammatory, anti-oxidant, anti-microbial, and anti-tuberculosis activity, while certain derivatives are used for therapeutic purposes. Aryl azo dyes are widely used due to their excellent physicochemical properties (primarily high value of the molar extinction coefficient and great resistance to light and wet processing) and the fact that can be obtained in a simple method of diazotization and coupling. In this paper, three new dyes of 6-hydroxy-5-(hydroxy substituted phenylazo)-4-methyl-2-oxo-1,2-dihydropyridine-3-carbonitriles were synthesized by a diazo coupling reaction starting from aminophenols (2-, 3- and 4-substituted) and 6-hydroxy-4-methyl-2-oxo-1,2-dihydropyridine-3-carbonitrile as coupling components. The obtained dyes were characterized by melting point, IR, NMR, and UV-Vis spectroscopy. Given the fact that the structure of the molecule and interactions obtained with the surrounding medium can affect its activity, the possibility of azo hydrazo tautomerism has been studied, as the influence of the position of the substituent present (orto-, meta- and para position). In addition, the effect of the solvent used was determined by applying a solvatochromic model using the LSER method (linear solvation energy relationship). Obtaining information about the inter- and intramolecular relationships that newly synthesized compounds can achieve may be of great importance for all further investigations and their potential application as biologically active compounds.

Key words: *Aryl azo pyridone dyes, carbonitrile, synthesis, azo-hydrazone tautomerism, solvatochromism, intermolecular interactions*

SUNFLOWER OIL WITH VITAMIN D: PRELIMINARY INVESTIGATION OF ENRICHMENT POSSIBILITY

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Abstract

Fat soluble vitamins, including vitamin D, are not sufficiently represented in the human diet. Although vitamin D can be synthesized in the body by direct exposure of the body to the sun, often people don't get enough sun exposure to assure enough vitamin D. Previous research has established that vitamin D deficiency is considered to be a highly prevalent nutritional problem worldwide. Vitamin D plays an important role in the optimal health including mediating calcium and phosphorus absorption, bone health metabolism, reducing cancer risk, prevention of cardiovascular diseases and insulin resistance. Optimal intake of vitamin D is an important issue for all races, ages and genders. Fatty fish and oil from the liver of various fish, as natural sources of vitamin D, are rarely present in the human diet worldwide, wherefore food fortification is a potential way to improve intake of vitamin D in the population. In order to select an appropriate food as a carrier for vitamin D fortification, several factors such as availability, cost, and stability during the cooking process should be considered. In addition, it should be noted that the amount of added vitamin D should be high enough to provide an adequate amount, and on the other hand, to prevent the risk of excessive intake of vitamin D. Vitamin D is, as previously mentioned, fat soluble, while vegetable oils and fats are present in the daily diet, so the aim of this work was to enrich sunflower oil with vitamin D3 (cholecalciferol). Cold-pressed oils are mainly used as salad oils, without additional heat treatment, which is why cold pressed sunflower oil was used for fortification. On the other hand, high oleic acid content provide good oxidative characteristics, so high-oleic sunflower oil was chosen. Fortification achieved a vitamin D3 content of 210 µg/100 ml in this oil. A portion of 15 ml of sunflower oil contains 31,48 µg of vitamin D3, while a portion of 5 ml contains 10,5 µg of vitamin D3.

Key words: *cold pressed oils, sunflower oil,food fortification, vitamin D*

FOOD SUPPLEMENTS – IS THERE A RISK OF VITAMIN AND MINERAL OVERDOSAGE?

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Abstract

Along with change of dietary habits, food supplements have emerged as one of possible intervention strategies to fight micronutrient deficiency. Despite the popularity of food supplements, the consumption of which has increased dramatically in the last few yaers, a plethora of associated risks inevitably follows. Vitamins and minerals, alone or in combination, present the most commonly used categories of foods supplements and this paper reviews the occurences of vitamins and minarals in doses higher then allowed, considering notifications registered on Rapid Alert System for Food and Feed (RASFF) portal within 2011-2022 timeframe. Data related to selected classes of substances were manually extracted and evaluated in terms of compliance with regulation estabishling maximum amounts of vitamins and minerals allowed in food supplements. Following this criterion, over a hundred notifications were recorded, revealing 113 cases of too high intake/risk of overdosage of vitamins and/or minerals. Non-compliances were not evenly distributed among these two groups of micronutrients, with 92% of violations referring to exceeded vitamins' tolerable upper intake levels, nor within the vitamins and minerals themselves. Too high intake of vitamin B6 was most often recorded (46 cases), followed by risk of overdosage/high intake of nicotinic acid (17), vitamin D (17), vitamin E (10), vitamin A (10), folic acid (2) and vitamin C (1). Notifications related to exceeded minerals' tolerable upper intake levels were significantly less represented and referred to the three minerals, zinc, iodine, and selenium, with a total of 9 recorded cases. In the notifications where the doses were stated, they sometimes exceed the recommended daily intake by hundereds or even thousands folds, and a case of poisoning (hypercalcemia) with one such supplement has also been recorded. The evaluation of the risk associated to the intake of high doses of vitamis and mineras from food supplements is particulary challenging due to frequent and different exposure sources. Therefore, improved quality control procedures and monitoring programs as well as adding complexity to the potential evaluation of the risk associated to the consumption of food supplements should be pursued in order to avoid undesirable products and resolve this problem in the best interest of public health.

Key words: *food supplements, vitamins, minerals, overdosage.*

UNAUTHORISED SUBSTANCES IN FOOD SUPPLEMENTS - PHOSPHODIESTERASE-5 INHIBITORS

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Abstract

Considering high prevalence of use of food supplements, especially their expansion in the last decade due to easy access on the internet, a serious associated safety issues associated have been raised. In order to meet the expectation of their customers, some producers have turned to the illict and dangerous practice of product adulteration with unauthorized synthetic adulterants. Food technologies should be a key in meeting the dual challange of enhancing both the quality and safety of food supplements. The Rapid Alert System for Food and Feed (RASFF) was established in order to speed up the flow of information in order to enable a quick reaction when risks to public health are discovered in the food chain. RASFF provides a tremendous database of countless food hazards. The aim of this paper was to search the RASFF database (criteria: food category "dietetic food, food supplements, fortified food", hazard category "composition") for the 2011-2022 period, in order to detect food supplements adultereted with unauthorized substances from the group of phosphodiesterase-5 inhibitors (PDE-5). The RASFF database was examined electronically and manually, and all occurrences of PDE-5 inhibitors and their synthetic derivatives were individually verified and counted. The records showed more than a hundred notifications, and their distribution by year was fairly even with the maximum of 33 notifications in 2019. But if we look at notifications related to PDE-5 inhibitors in relation to the total number of notifications for food supplements in a given year, then in 2022 we have a sharp peak where almost 40% of notifications refer to PDE-5 inhibitors. In a total of 179 notifications related to food supplements adulterated with PDE-5 inhibitors, 235 occurrences of PDE-5 inhibitors and their analogues were recorded, as a substantial number of supplements showed simultaneous presence of several unauthorized PDE-5 inhibitors and/or their analogues. The most frequent were those of the siledenafil group (66%), followed by the tadalafil group (28%), vardenafil (5%) and finally avanafil with only one notification. Although sildenafil and tadalafil were most frequently detetcted, their analogues and synthetic derivatives were also found in 61 cases, and the numbers continued to increase over the years due to producers' attempts to avoid adulterant detection by existing analytical methods.
A multidisciplinary approach that includes scientists in food technology, nutrition and public health is essential to our ability to respond to the global problem of the illegal practice of using unauthorized substances in food supplements.

Key words: *PDE-5 inhibitors, analogues, food supplements, adulterants.*

USAGE PHOSPHOMOLYBDENUM AND BRIGGS-RAUSCHER METHODS IN MEASURING ANTIOXIDANT ACTIVITY OF MARIGOLD EXTRACTS

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Abstract

Marigold (Calendula officinalis L.) is an aromatic plant from Asteraceae family. The whole plant contains active phytochemicals, which are responsible for numerous biological potentials. The goal of this study was to measure the antioxidant and anti-inflammatory activities of marigold extracts. Samples of marigold (leaves, flowers, stems and roots) were harvested in Lukavica 2020 and 2021, and in Hotonj 2021. For measuring the antioxidant and anti-inflammatory activities, these samples were subjected to Soxhlet and ultrasonic extractions usage 96% ethanol as a solvent. Apart from that, to measure the anti-inflammatory activity, samples were subjected to cold and hot extractions on a magnetic stirrer, and cold extraction on a improvised vertical stirrer usage distilled water as a solvent. Phosphomolybdenum and Briggs-Rauscher (BR) methods were used in measuring the antioxidant activity of isolated marigold extracts. The anti-inflammatory activity of these extracts was measured by protein denaturation assay. In phosphomolybdenum method, ascorbic acid (AA) and curcumin (C) were used as standard solutions. According to this method, the leaves extract, which was obtained by Soxhlet extraction of leaves (harvested in Lukavica 2020), has showed the best antioxidant activity (136.28 ± 5.32 $mg_{EAA}/g_{extract}$ and 469.23 ± 22.23 $mg_{EC}/g_{extract}$). On the other hand, gallic acid (GA) and curcumin (C) were used as standard solutions in BR method. In this method, the best antioxidant activity was showed by the flowers extract, obtained by Soxhlet extraction of flowers, which were harvested in Lukavica 2020. Briggs-Rauscher antioxidant indexes (BRAI) of this extract were 0.7067 (calculated over the standard of GA) and 0.2086 (calculated over the standard of C), at a concentration of 1 mg/mL. In protein denaturation assay, the roots extract, which was obtained by cold extraction of roots (harvested in Lukavica 2021) on a magnetic stirrer, has showed the best anti-inflammatory activity (80.37 ± 0.22 %), at a concentration of 1 mg/mL. In conclusion, marigold extracts have indicated significant values of antioxidant and anti-inflammatory activities according to phosphomolybdenum and Briggs-Rauscher methods, and protein denaturation assay, respectively.

Key words: *marigold, antioxidant activity, anti-inflammatory activity, phosphomolybdenum method, Briggs-Rauscher method, protein denaturation assay*

STUDY OF THE EFFECTS OF ACTIVE BROMINE SPECIES PRESENCE IN ELECTROLYTIC DESULFURIZATION OF SUBBITUMINOUS COAL

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Abstract

The removal of organic and inorganic sulfur from the Bogovina Basin subbituminous coal by electrochemical redox reactions was performed. The effect of presence of active bromine species on the desulfurization process was monitored. The desulfurization was performed in inorganic acidic solutions that contained different bromide concentrations and in pure acid solution. To determine the optimal conditions for the desulfurization process, polarization curves were recorded in three different electrolytes: 0.1 M H_2SO_4, 0.1 M H_2SO_4 + 0.01 M KBr, and 0.1 M H_2SO_4 + 0.1 M KBr using graphite and dimensionally stable anode (DSA) electrodes as the anode, while in all cases stainless steel S31603 electrode was used as cathode. By analyzing the results obtained from the polarization curves, 0.1 M H_2SO_4 and 0.1 M H_2SO_4 + 0.1 M KBr were chosen as the most suitable electrolytes. Also, it was found that the DSA anode showed better results in terms of energy efficiency of the process compared to the graphite anode and therefore it was selected for the coal desulfurization process. It is considered that finely suspended coal particles in an electrolyte can behave according to bipolar electrochemistry. Coal was treated for 4 hours in two selected electrolytes. The suspension was sampled at different times up to 240 min from the beginning of the process. Sulfur content in coal was determined by elemental analysis. The results showed that the sulfur content decreases faster in the case of the electrolyte containing KBr, i.e. that the desulfurization effect is significantly better than in the case of the system containing only H_2SO_4. It can be concluded that active bromine species accelerate the desulfurization process and thus improve energy efficiency.

Key words: *subbitominous coal; oxidative desulfurization; organic sulfur; active bromine species; electrolytic desulfurization; DSA*

ANTIMICROBIAL TREATMENT OF INSOLES WITH *Agrimonia eupatoria* EXTRACT FOR FEET PROTECTION AGAINST *Callositas et Clavus*

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Abstract

The aim of this work was to point out the problem faced by people whose feet are affected by Callositas et clavus and to find appropriate ways of processing shoe insoles, which would have an antimicrobial and anti-inflammatory effect, thus reducing the spread of clavus and reducing the possibility of their occurrence. Antimicrobial treatment of shoe insoles was done by screen printing using a paste obtained from modified alginate (CHT-NV) and modified bentonite (MB) to which various components were added, such as salicylic acid (SK), lactic acid (MK), castor oil (RU) and Agrimonia eupatoria plant extract (E). The processed samples for sorption and dielectric properties, the degree of coloration and the antimicrobial effect of the insoles after printing and after exposure to the influence of artificial sweat were tested. Based on the results of testing the dielectric properties of inserts printed with alginate paste and modified bentonite, it is observed that the addition of Agrimonia eupatoria extract increase the conductivity, while the addition of lactic acid decrease the conductivity. In samples printed with a paste to which Agrimonia eupatoria extract and salicylic acid were added, after treatment with artificial sweat there was a drop in conductivity compared to the sample before treatment. By researching the antimicrobial properties of printed insoles for shoes against Staphylococcus aureus and Escherichia coli bacteria, it was established that the samples printed with paste with the addition of lactic acid show the best effect. The antimicrobial effect of printed inserts on Candida albicans is reflected through contact inhibition for samples printed with alginate paste and modified bentonite UL-(CHT+MB), then with paste with the addition of salicylic acid and Agrimonia eupatoria extract UL-(CHT+MB+SK+E), lactic acid UL-(CHT+MB+MK) and castor oil UL-(CHT+MB+RU). Also, it was established that the exposure of printed samples to the influence of artificial sweat results in a reduction of the antimicrobial effect in all tested samples, except for samples printed with alginate paste and modified bentonite UL-(CHT+MB)+Z and with the addition of lactic acid UL-(CHT+ MB+MK)+Z to Candida albicans yeast.

Key words: *Clavus, antimicrobial printing, modified bentonite, Agrimonia eupatoria.*

MERIPILUS GIGANTEUS (*AGARICOMYCETES*): NUTRITIONAL PROFILE AND CYTOTOXIC ACTIVITY AGAINST MCF-7 AND HEPG-2 CELLS

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Abstract

The aim of this work was to investigate nutritional profile and cytotoxic activity against MCF-7 and HepG-2 cells of autochthonous mushroom species Meripilus giganteus. Total protein content in the analyzed fungal species was 17.7%. Among the essential amino acids, leucine was the most abundant (7.0 mg/g d.w.). The total essential and non-essential amino acid contents were 32.8 and 122.7 mg/g d.w., respectively. Fatty acid composition of M. giganteus showed that polyunsaturated fatty acids (PUFA, 49.9% of total FA), monounsaturated fatty acids (MUFA, 34.3% of total FA) and predominated over saturated fatty acids (SFA, 15.7% of total FA). The dominant fatty acids were linoleic (48.5%), oleic acid (32.5%), and palmitic acid (13.1%). The most abundant macroelement in M giganteus was potassium, followed by copper, magnesium and calcium, while zinc dominated in microelements. Three phenolic compounds were quantified in ethanolic extract of M. giganteus HPLC – DAD with the highest amount of p-OH-benzoic acid and protocatechuic acid reaching 23.9 d.w. and 1.26 µg/g d.w., respectively. The ethanol extract was the most potent in cytotoxic activity against MCF-7 after 72 h (93.14% at 900.00 µg/mL). Our data suggest that the mushroom species M. giganteus can be considered as a promising food supplement or spice in the regular diet.

Key words: *mushroom, nutritional profile and cytotoxic activity*

RESONANCE-ASSISTED HYDROGEN-BRIDGED RINGS: PARALLEL ALIGNMENT IN CRYSTAL STRUCTURES AND SIGNIFICANT NONCOVALENT ATTRACTION

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Abstract

Resonance-assisted hydrogen-bridged rings (RAHB) are promising structures in material design due to synergistic effects between hydrogen bonding and resonance. We investigated mutual contacts between RAHB ring structures deposited in the Cambridge Structural Database (CSD), as well as contacts between RAHB rings and C_6-aromatic fragments. Stacking interactions in crystal structures are identified by parallel alignment of interacting fragments and a characteristic distance between the planes of the interacting fragments, which is between 3.0 and 4.0 Å. The existence of stacking interactions is then confirmed by quantum chemical calculations of interaction energies at dimer model systems. Namely, more than 90% of mutual RAHB/RAHB contacts found in the CSD are parallel and anti oriented. A smaller part of RAHB/C_6-aromatic contacts (around 60%) is in parallel orientation. Both RAHB/RAHB and RAHB/C_6-aromatic contacts typically form parallel layers at a specific distance (between 3.0 and 4.0 Å), which distinguishes them from benzene/benzene parallel contacts found in the CSD, where layers are not formed. The most abundant RAHB ring types found in the CSD are used as model systems for quantum chemical calculations of interaction energies. Malonaldehyde ($H_4C_3O_2$), its mononitrigen analogue (H_5C_3NO) and dinitrogen analogue ($H_4C_2N_2O$) are used as model systems for RAHB rings, while benzene molecule is used as a model system for a C_6-aromatic fragment. RAHB/RAHB interactions can be quite strong (up to -4.7 kcal/mol in case of H_5C_3NO/H_5C_3NO dimer). RAHB/benzene interactions are generally weaker (up to -3.5 kcal/mol in case of $H_4C_3O_2$/benzene dimer), but they can be also stronger than the corresponding RAHB/RAHB interactions, depending on the system. Both RAHB/RAHB and RAHB/benzene interactions are stronger than benzene/benzene stacking interactions (-2.7 kcal/mol). Stacking interactions can remain strong in some systems even when placed to large horizontal displacements. For example, benzene/benzene stacking preserves 70% of its maximum strength upon shifting to the displacement of 5.0 Å. Stacking interactions of RAHB rings can, in some cases, preserve similar portion of their strength (around 70%) at large displacements.

Key words: *RAHB rings, stacking interactions, CSD*

ENTRAINED FLOW GASIFICATION MODELING VIA INTEGRATED THERMODYNAMIC EQUILIBRIUM AND ARTIFICIAL NEURAL NETWORK APPROACH

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Abstract

Waste gasification is one of the most promising waste-to-energy processes, mainly due to high carbon conversion, high efficiency and polygenerative opportunities. The biggest obstacle in gasification process design is the complex nature of gasification mechanism, as several phenomena at extreme process conditions take place simultaneously, which makes it difficult to examine the process experimentally. There are several approaches for gasification process modeling, mainly kinetic and thermodynamic equilibrium approach, where the latter is the most common. This study is an attempt to integrate thermodynamic equilibrium approach with Artificial neural network (ANN) in order to model entrained flow gasification of municipal solid waste (MSW), and thus obtain further insight in relative impact of different process parameters on output parameters. Input parameters used in this study are waste composition (ultimate and proximate analysis composition) and operating parameters (type of gasifying agent, equivalence ratio, temperature and pressure), while output parameters are syngas composition, heating value and cold gas efficiency. Different waste sample compositions were taken from the literature and used in Aspen Plus simulation of entrained flow gasification, where sensitivity studies were performed. Obtained results are used as a training data for developed ANN model, and cross validation was used for the model verification. Also, relative influence of different parameters on syngas characteristics was quantified. Results show good agreement with simulated data, as numerical methods confirmed high model accuracy. The proposed model is a powerful tool which can significantly facilitate the study of entrained flow gasification process.

Key words: *Municipal solid waste, Gasification, Process simulation, Artificial neural network*

SCREENING OF *CLOSTRIDIUM* SP. FOR BIO-HYDROGEN PRODUCTION POTENTIAL FROM LIGNOCELLULOSIC BIOMASS

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Abstract

Following the rising environmental awareness and severe pollutions caused by burning of fossil fuels, the current society has demanded for sustainable and renewable energy sources. Hydrogen serves as a clean energy carrier with zero emission as it produces only water as the product of combustion. In comparison to thermochemical conversion techniques (such as autothermal and steam reforming, and partial oxidation), biological techniques of hydrogen production (such as dark fermentation) is less energy intensive and more environmentally friendly. However, biological hydrogen production faces some significant barriers in wide-scale application, especially due to its high production cost. Therefore, some feedstocks, such as lignocellulosic biomass can serve as abundant, renewable and low-cost feedstock for bio-hydrogen production and improve its overall economic competitiveness. Lignocellulosic biomass can be hydrolyzed into simple sugars, such as glucose and xylose, which are excellent substrates for hydrogen-producing microbes. In this study, the biohydrogen production performances of 6 hydrogen-producing strains of Clostridium sp., including Clostridium pasteurianum CH1, CH4, CHn as well as Clostridium butyricum CGS, CGS2, CGS5 have been compared. The dark fermentation of Clostridium spp. was performed utilizing Endo medium as cultivation medium with glucose and xylose as model carbon sources. Among the Clostridium spp. examined, C. butyricum CGS5 achieved the highest bio-hydrogen production performance of 440 mL when utilizing glucose as carbon source. On the other hand, C. butyricum CGS obtained the highest bio-hydrogen performance of 240 mL when utilizing xylose as carbon source. These results provide useful insights for future utilization of lignocellulosic biomass as feedstock for low-cost and sustainable biohydrogen production.

Key words: *Biohydrogen, Clostridium, lignocellulosic biomass, renewable energy*

PARTICLE SIZE DISTRIBUTION OF WHITE CHOCOLATE WITH RESISTANT STARCH

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Abstract

White chocolate is produced of cocoa butter, sugar, milk powder, lecithin and vanillin where the particles of sugar and milk solids are covered by the mixture of cocoa butter and milk fat. Unlike dark and milk chocolate, white chocolate does not contain dark cocoa solids rich in polyphenol components, minerals, and dietary fiber. Thus, the nutrition value of this type of confectionery product is very low compared to dark and milk chocolate.
Resistant starch is a part of insoluble dietary fiber and it could be recognized as functional food ingredient in some types of confectionery products that lack dietary fiber. Accordingly, in the present study, 5%, 10%, and 15% of white chocolate was substituted with resistant starch in order to increase dietary fiber content of enriched white chocolates. The obtained samples are marked as WC0 - control sample of chocolate and WC5, WC10, and WC15, depending on the amount of resistant starch added.
Consumer acceptance of chocolate depends primarily on the appearance and taste, but also on mouth feel, which mainly depends on the particle size and the viscosity of the molten chocolate mass. Particle size distribution (PSD) influences the structure, rheology, and texture of chocolate. The particle size distribution (PSD) of resistant starch and chocolate samples was determined using a laser diffraction particle size analyzer (Mastersizer 2000, Malvern Instruments, UK). The Scirocco dispersion unit was used for dispersing resistant starch in the air, whereas a Hydro 2000 μP dispersion unit was used for dispersing chocolate in sunflower oil. The results were quantified as the volume-based PSD using Mastersizer 2000 software.
White chocolate has multimodal particle size distribution. The volume mean diameter D[4,3] of resistant starch is 12.60 μm while the parameter D[4,3] of white chocolate is 21.32 μm. Taking into account the fact that particles in chocolate are desirable to be in interval 15–30 μm, resistant starch did not have undesirable impact on PSD of enriched white chocolates since diameter D[4,3] amounts 21.13 μm in WC5, 19.34 in WC10 and 18.82 μm in WC15.

Key words: *white chocolate, resistant starch, dietary fiber, particle size distribution*

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OAK/BEECH BIOCHAR POTENTIAL IN REMOVING PHENOLIC COMPOUNDS FROM WASTEWATER

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Abstract

Phenol and its derivatives are widely used chemicals in many industries, such as petroleum, pharmaceutical, leather, pesticide, paper and plastic industries. These compounds penetrate into ecosystem (water, soil, air) and reach the food chain. These pollutants are highly toxic, carcinogenic and have negative effect on ecosystem and the living organisms. The World Health Organization (WHO) recommends that the maximum allowable concentration of phenol in potable water is 0.001 mg/L. The removal of phenols from water is quite challenging, and therefore a number of methods have been developed for that purpose. The adsorption process has received particular attention owing to its high efficiency, simplicity, and easy operation, as well as a variety of the used adsorbents. One of the low-cost and eco-friendly adsorbents that showed high efficiency in the removal of organic pollutants from water is biochar. The aim of this work was to examine the effectiveness of using biochar as an adsorbent for phenol removal from synthetic wastewater. Biochar was obtained by pyrolysis at 700°C from waste oak/beech biomass and its detailed physicochemical characterization was performed. The obtained characterization results were correlated with the adsorption capacity achieved under different process parameters, indicating that this sustainable carbon material can be considered as promising adsorbent in phenol-containing wastewater treatment processes.

Key words: *Biochar, Phenol, Adsorption, Wastewater treatment*

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OPTIMIZATION OF MEDIUM COMPOSITION FOR PRODUCTION OF BIOCONTROL AGENT TRICHODERMA HARZIANUM

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Abstract

Maize is the most important field crop in Serbia. This agricultural crop, like others, is susceptible to infection by a number of pathogens. Among the most important pathogens, Helminthosporium carbonum and Penicillium spp. were mentioned. Protection of maize from fungal pathogens is mainly controlled by the application of fungicides which are known to have a negative impact on the environment. However, the discovery of new, biological ways of protection would enable a significant reduction of negative effects on the environment and human health. The usage of microorganisms in biological protection is becoming very important, especially in organic and integral production. Trichoderma is certainly a genus that has great potential in protecting plants from fungal pathogens, so the aim of this research was to optimize the medium composition for the production of Trichoderma harzianum biocontrol agent effective against the maize pathogens, H. carbonum and Penicillium sp. To optimize the composition of the cultivation medium in terms of glucose (g/L) (10; 30; 50), soy flour (g/L) (3; 5; 7) and K_2HPO_4 (g/L) (1 ; 2 ; 3) content, experiments were carried out in accordance with Box-Behnken design, and optimization of multiple responses was performed using the concept of desirability function. The experiment was included 15 experiments which were carried out in Erlenmeyer flasks with 100 mL of well-defined medium. The results showed that the maximum inhibition zone diameters of H. carbonum (60 mm) and Penicillium spp. (23.69 mm) as well as the maximum production of T. harzianum biomass (0.4736 g/L) was achieved when the initial content of glucose, soy flour and K_2HPO_4 were 10.03 g/L, 3.26 g/L and 1.03 g/L, respectively. The obtained results show that T. harzianum has a significant antagonistic effect on the examined maize pathogens and, at the same time, obtained results represent the first and significant step towards further development of these bioprocesses.

Key words: *Biological control, Trichoderma harzianum, Maize diseases, Medium optimization, RSM*

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EXTRACTION OF PECTIN FROM SUGAR BEET WASTE AND DETERMINATION OF ITS FUNCTIONAL PROPERTIES

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Abstract

Currently, the essential exploitation of the wastes from food and agricultural industries that contribute to environmental contamination is the degradation of the aimed at the production of useful products such as vitamins, polypeptides, proteins, oligosaccharides, polysaccharides, enzymes, hormones, and others. One of the most important agro-industrial wastes from the sugar refining industry in terms of underexploited opportunities and generated levels is exhausted sugar beet Pulp. Pectin, as an useful biowaste product, has been described as an emerging prebiotic with the ability to modulate the bacterial composition of the colon microbiota, being able to exert beneficial effects on health. Sugar beet pectin showed great promise as emulsifiers for both food and non-food purposes, and could represent valuable subsidiary products for the sugar beet industry. Therefore, the objective of this study was to characterize the properties of pectin extracted from sugar beet pulp by conventional acid extraction at different extraction time (3 and 6 h) and with different acids (0.5 M HCl, 5 M HCl and 5 M HNO_3) for adjusting pH 1. The research involved determination of the antioxidant properties of pectin by DPPH, ABTS and CUPRAC assays, as well as the application of Fourier-transform infrared spectroscopy (FT-IR) to reveal the molecular structure of isolated pectin. The yields of the extracted pectins ranged from 20.4% to 37.8%. The optimum extraction conditions were the temperature of 80°C, time of 3 h, and pH of 1 using 5 M HCl. The type of acid used (HCl or HNO_3) had the greatest effect on the characteristics of extracted pectins. The antioxidant activities of sugar beet waste pectin obtained using 0.5 M HCl during 6 h was the highest in all studied methods. The FT-IR spectra demonstrated several relevant peaks and a presence of various chemical groups, originating from pectin as a biopolymer. Overall, the results offered a promising approach to convert the sugar beet waste to pectin as a value-added product using conventional acid extraction with improved pectin properties.

Key words: *sugar beet waste, pectin, antioxidant activity, FT-IR.*

THE USE OF 3D-PRINTING TECHNOLOGY IN THE FOOD INDUSTRY

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Abstract

The development of 3-dimensional printers has allowed a great development in many other subsidiary and parallel areas, from the industrial production to the final user. This technology has also found a good deal of applicability in the food supply chain, particularly in areas of industrial processing, culinary preparations or even consumer applicability. Hence, the aim of this work is to make a balance of these applications, which is pivotal for the success of this technology, and to show its potentialities in the domain of food. The findings suggest that, although 3D printed food is still a novel trend, its adoption by professionals and consumers is rising and expected to experience a huge growth in the future, powered by the technological developments allied to food properties design. The foods that can be printed in 3D are limited and that is dependent on the food processing required for each food. Material extrusion is by far the most common process for 3D printing food. This requires paste-like materials to work with (inputs) such as purées, mousses, and other viscous foods like, for example, chocolate ganache. Although 3D printers are particularly useful for architecting intricate food shapes and designs, it must be kept in mind that, in most times, they do not actually cook the ingredients. In this way, either the edibles are ready for consumption or, alternatively, they must be cooked in a separate equipment after the printing process finalizes. However, there are exceptions, and a case can be cited in which the 3D-printig is coupled to heating – the case of the PancakeBot, which is a machine that makes pancakes by extruding the batter directly onto a hotplate. Some advantages of 3D-printing include easy reproducibility, unconventional food production and consumption, or personalization of meals. Nevertheless, there are also disadvantages, like the time necessary to print one individual food item. For example, while a very simple six-layer design can be printed in a sort time (7 minutes), more detailed food designs take more than 45 minutes per unit. This can compromise scale up of the technology from laboratory to industrial scale. In conclusion, this technology has much to offer to the food sector, either at the industrial level or for culinary preparations, and the future holds a great deal of opportunities to further explore its applications.

Key words: *food processing, modern technology 3D-printing, industrial process.*

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ADSORPTION PROPERTIES OF CONJUGATES OF PLUM SEED PROTEIN ISOLATES AND CAFFEIC ACID

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Abstract

Proteins are natural macromolecules important because of their biological function, but also because of their techno-functional characteristics. The techno-functionality of proteins is related to their physico-chemical properties (solubility, viscosity, foaming, gelling, water and oil binding) that affect the appearance, texture and stability of the product. In recent years, much attention has been paid to proteins from plant sources, especially those that can be isolated from alternative sources, such as by-products of the food industry.

One of the aspects of proteins application, due to their good functional characteristics, is their use as a polymer emulsifiers, for stabilization of various dispersed systems, or as carriers for bioactive molecules encapsulation. However, thanks to intensive researches in this area, it was observed that the functional properties of protein isolates can be further improved by their conjugation with phenolic compounds.

The aim of this research was to examine the surface activity of the protein isolate obtained from plum seed, as well as the conjugates obtained by the interaction of the isolate and caffeic acid. Also, properties of O/W emulsions stabilized with the protein isolate and obtained conjugates were investigated. The obtained results indicated potential for application of obtained conjugates for emulsions stabilization.

Key words: *protein isolates, conjugates, surface activity, emulsions stability.*

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WINE PRODUCED FROM THE SERBIAN AUTOCHTHONOUS *PROKUPAC* VARIETY ENRICHED WITH SELENIUM

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Abstract

Autochthonous variety Prokupac (Vitisvinifera L.) is mostly cultivated in the south region of Serbia due to the suitable climatic and soil properties for the cultivation of this variety. Red wines produced from Prokupac grapes are quality table wines with well known and unique taste. After the wine processing, produced waste amounts are high and known as a source of valuable, bioactive components such as polyphenols. Selenium (Se) is an essential micronutrient naturally found in soil. However, normal diet does not meet the daily human needs for Se, due to its low concentration in soil, which reflects on its content in food.
The aim of the study was to produce red wine with increased Se content. Se was added in grapes must before the fermentation process (2.5 mg Se/kg and 5.0 mg Se/kg) using Na_2SeO_3. Total Se content was determined by ICP-MS before and after 21 day of fermentation with maceration. The influence of applied Se concentrations on yeasts' growth was monitored due to the potential negative impact of high Se concentration. Furthermore, change of the total phenolic compounds content was monitored in wines and grapes pomace left after the wine processing.
Se content in control wine sample was 0.132±0.012 mg Se/L, while the concentrations in enriched wines increased, reaching 0.257±0.082 mg Se/L, (2.5 mg Se/kg) and 0.294±0.041 mg Se/L, (5.0 mg Se/kg). Total phenolic compounds content in wines reached 828.75±24.33, 1079±93.15 and 1033±66.4 mg GAE/L in control, 2.5 mg Se/kg and 5 mg Se/kg samples, respectively. The negative impact of added Se on yeasts' growth was not found. According to results, the addition of 2,5 mg Se/kg in grapes must is more suitable for Se and phenolic compounds enrichment of Prokupac wine. In addition, it was proved that ethanol extract of garapespomaces contain high amount of total phenols. This content is higher in pomace left after wine processing without added selenium (3142.21±28.69mg/L) than in pomaces from wines with selenium, which reached 2836.88±115.79 mg/L and 2804.07±28.73 mg/L in samples with 2.5 mg Se/kg and 5.0 mg Se/kg, respectively.

Key words: *Prokupac, Wine, Selenium, Yeasts, Phenolic compounds, Waste*

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INTERACTIONS BETWEEN CHITOSAN AND NONIONIC SURFACTANT IN THE AQUEOUS MEDIUM

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Abstract

Chitosan (Ch), derivative of chitin, is a polysaccharide which carries free amino and hydroxyl groups along its backbone. Due to its biodegradability, biocompatibility, antibacterial and antiviral activity, it has great potential in cosmetic, pharmaceutical and food industry. The deacetylation degree of the chitosan and its solution conditions have an impact on the charge density along the chains, and therefore on its flexibility and conformation. These properties, together with the hydrophobicity of the backbone, play an important role in chitosan–surfactant interactions. Polymer/surfactant interactions in aqueous systems significantly change the system's properties at the interfaces and in the solution, which can result in different effects, such as emulsifying, solubilization, increasing viscosity and colloidal stability. Most of studies on polymer/surfactant pairs are concerned with surfactants which cannot be applied in food products. Polysorbates are non-ionic surfactants widely used in food products. They are derived from PEG-ylated sorbitan esterified with fatty acids. The hydrocarbon chains provide the hydrophobic nature of the polysorbates, while the hydrophilic nature is provided by the ethylene oxide subunits. Despite the marked importance of chitosan and nonionic surfactants, very little is known about the assembly and physicochemical properties of these polymer/surfactant pairs. The purpose of this study was to investigate the interactions in the system chitosan, cationic polysaccharide, and nonionic surfactant (Tween 20) in aqueous solution, which were monitored by surface tension, electrophoretic mobility and size distribution. Chitosan–nonionic surfactant interactions are weak nature. The chitosan–Tween 20 may interact by hydrogen bonding between the hydroxyl and carbonyl groups of Tween 20 and the amine, ammonium ions and hydroxyl groups of the chitosan, in addition to hydrophobic interactions between the Tween 20 tails and chitosan hydrophobic sites. The current research provides information about interactions in the chitosan-nonionic surfactant aqueous mixtures that are important regarding many practical applications, especially in food preparations. Overall, small variations in the structure of surfactants can lead to significant differences in their intermolecular interactions and association with polymers.

Key words: *chitosan, Tween 20, interactions*

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REMOVAL OF EMERGING COMPOUNDS IN POLLUTED WATERS BY RICE HUSK BIOCHAR

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Abstract

Annual rice production worldwide is almost 740 million tons. The major producers are China, India, Vietnam, Thailand, United States and Pakistan. It is estimated that the amount of rice husk can reach 23% of the total mass production, which represents almost 150 million tons per year generated worldwide in rice processing. One of the main products of pyrolysis is the char. For better performance and improvement of its physicochemical properties it is necessary to make temperature changes. In this study, different temperatures have been tested for the pyrolysis of rice husk, and the biochar obtained from the process have gone used through an evaluation to test their yield in the removal of emerging compounds such as azithromycin (AZT) and erythromycin (ERY). For this, pyrolysis of rice husk has been carried out at temperatures of 450, 500, 550 and 600 ºC, the biochars have been characterized by ultimate analysis and proximate analysis, as well as specific surface area tests. Then different adsorption tests have been carried out with a drug (AZT and ERY) solution prepared in the laboratory of 200 mg L^{-1}. All biochars have been found to present removal percentages higher than 95%. Therefore, obtaining biochar from rice husk at any temperature and using it in the removal of high molecular weight compounds is quite suitable. With the results of this study, progress is made in obtaining materials that can be used as adsorbents for the removal of emerging pollutants, such as macrolide antibiotics, characterized by their high molecular weight and difficulty to remove from sources of waters. It has been found that the biochar obtained from the pyrolysis process all present high removal efficiencies for both pollutants.

Key words: *biochar, emerging compounds, polluted water, removal, azithromycin, erythromycin*

ASSESSMENT OF THE REACTIVITY IN PASTES IN DIFFERENT MIXTURES OF LIME AND RICE HUSK BIOCHAR

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Abstract

Biochar has unique properties such as porous structure, large specific surface area, complex surface groups, and stable chemical properties. Biochar comes from the pyrolysis process, in which the volatile matter, constituted mainly by hemicellulose, cellulose, and polysaccharides, is mostly eliminated, and its degradation depends on the temperatures of the process; making the biochar mainly composed of lignin. The replacement of cement by biochar/fly ash depends on the content of silica and its chemical reaction with the cement compounds. The reactions between siliceous or silico-aluminous material that chemically reacts with calcium hydroxide at ordinary temperatures forms compounds that have cementitious properties.
The rice husk is characterized by its high content of silica, and that during the pyrolysis process it generates a considerable amount of biochar that can be used in different processes. The aim of this work is to evaluate several biochars from the pyrolysis process in the reactivity of lime pastes. For this, biochar has been obtained at four different temperatures (450, 500, 550 and 600 ºC), and they have been characterized by XRF, XRD, ICP-EOS, and particle size distribution, to determine their phases and their chemical composition. Biochar has been replaced in lime pastes in different proportions (5, 10, 15, 20, 25 and 30%), and exposed to different curing times (1, 3, 7, 14, 28, 56, 90 and 180 days). It has been found that all the replacements show reactivity within the lime pastes and that the percentage of 25% in all the biochar tested could be an adequate replacement. All the biochar obtained at different temperatures show high reactivity in all the replaced percentages, but it is the 20 and 25% that show the best performance on day 180. From day 28 to day 180 where the tests have stopped, according to the TGA analyzes, it was possible to show the pozzolanic reactions that were being produced in all the replacements and biochars tests. This demonstrates the feasibility of being used both in the production of Portland as well as a replacement for the manufacture of low-performance inputs. It has been observed that from the first day of curing the portlandite reaction occurs and the formation of C-S-H gels begins, but it is on day 180 that a more pronounced peak is evidenced in the range between 50 and 150 ºC, which is associated with this type of gels.

Key words: *Rice husk, pyrolysis, biochar, reactivity, lime paste*

CHARACTERIZATION OF STARCH ISOLATED FROM DIFFERENT POTATO VARIETIES

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Abstract

The aim of this study was to isolate and characterize starch from eight potato varieties. First, the basic chemical composition of the potato samples was determined, and then the isolation was carried out under laboratory conditions. The isolated starch was air dried, then ground and sieved through a 400 µm sieve. The basic chemical composition, thermophysical properties, swelling capacity and solubility index were determined in the obtained samples. The results showed that the potato variety SL 13-25 had the lowest starch content, while the variety Stilleto had the highest starch content. The content of protein, fat, ash and crude fiber was relatively low, indicating the high purity of all isolated starches. Retrogradation transition temperatures and enthalpies were lower compared to gelatinization temperatures and enthalpies. With increasing temperature, both the swelling capacity and the solubility index of all samples increased.

Key words: *starch, potato, isolation, characterization*

VALORIZATION OF STRAW PULP FOR THE PAPER INDUSTRY BASED ON THE WATER RESISTANCE OF PRINTS MADE WITH DIFFERENT PRINTING TECHNIQUES

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Abstract

Nowadays, all kinds of industries are facing surging prices and uncertainty about the supply of natural raw materials, which are closely related to their shortage. The paper industry and therefore, the graphic industry is facing with the same problem. The graphic industry supports all economic activities with its products, whether it is information, news, entertainment, education, advertising or packaging, so it can be said that printed products play a major role in daily life. Today, the packaging sector is developing and growing the most, in which the graphic and paper industry plays an important role in the production and design of packaging. Therefore, it is necessary to expand the sources of raw materials for the production of packaging, especially to annually available renewable sources. Considering the fact that packaging becomes waste very quickly after using the product it protects, from the moment of production until delivery to the consumer, the goal is to produce reusable packaging in an environmentally safe way without endangering the consumer or the product. Not only is it desirable that the packaging could be recycled for environmental reasons, but it is also important that it is of good quality and that it can carry printed information. In this research, studied papers as one of the most common substrates for printing and widely used packaging material were made from the pulp of recycled fibers refined with 30% pulp of cereal straw of the Croatian climate. Printed laboratory-made papers in full tone with conventional black ink by offset, flexographic printing and gravure printing were subjected to a test of chemical resistance to water. Given that, packaging most often comes into contact with water during transportation, storage and handling, recommendations for choosing the optimal printing technique when printing paper with straw pulp will be based on the tested water resistance of the prints.

Key words: *straw pulp, water resistance, packaging, prints, printing techniques*

FOOD STRUCTURE AND TEXTURE: INDUSTRIAL RELEVANCE AND MEASUREMENT TECHNIQUES

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Abstract

One of the most important properties of solid foods is texture, which corresponds to a set of physical properties, perceived by human senses such as audition or touch. These properties are linked to the internal structure of the material, this in turn being determined by the molecular interactions of its constituents. Cells play an important role in the structural characteristics of a food. For example, plant cells are surrounded by a cell wall that determines cell shape and intercellular cohesion, providing mechanical strength and rigidity, thereby defining the texture of plant foods. Additionally, texture is also associated with food composition. Among foods' components, starch is one that most contributes to texture changes. Starch is a relevant component in a diversity of bakery products, which are an important sector of the food industry globally and are part of regular diets of many people.

Hardness is a physical property of the material that is most used in texture evaluation. It is often fundamental in the quality of the product and can be decisive in its acceptability by the consumer (ex: crispy chips or soft bread). Besides the relevance for consumer acceptance, texture is also highly important in a more technological/industrial perspective. Some examples of the industrial relevance of texture include prevention of mechanical injuries to fruits all the way along the supply chain; selection of raw materials destined for processing, especially freezing, drying or canning; quantification of changes due to industrial food processing; in product development and in quality control.

There are two types of approaches used to assess food texture: through instrumental methods or by sensorial analysis. Instrumental methods encompass the measurement of the physical properties using equipment, like penetrometers or texturometers. They allow the quantification of a wide variety of textural properties, including hardness. In contrast, sensory tests are carried out by a number of panellists/judges, with or without training, in a tasting room, following standardized procedures. Since the information provided by both types of tests is complementing in many situations both are carried out and the correlation between sensory and instrumental texture is investigated, like in product development. When it comes to industrial processing, instrumental texture analysis is the viable option, for being easier, cheaper and faster. This work presents some case studies that evaluate textural properties in a diversity of bakery products, by both, instrumental measurements as well as sensorial evaluations.

Key words: *food processing, textural properties, industrial process, bakery products*

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DIFFERENTIATION BETWEEN FABA BEAN AND GRASS PEA FLOURS: HIERARCHICAL CLUSTERING OF LIPOSOLUBLE EXTRACTS

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Abstract

Being a nutritive and healthy food commodity, edible legumes – pulses (Fabaceae) are frequently used in daily nutrition of modern human population, both in raw form or incorporated as a part of various functional food products. However, reliable methodologies for controlling their authenticity are still not studied in the scientific literature. This work represents a novel approach for differentiation of edible legume flours according to the belonging botanical origin by coupling a technique of gas chromatography – mass spectrometry (GC-MS) with multivariate data processing tools. Twenty-one legume samples of : (i) Vicia faba L., also known as faba bean, fava bean or broad bean; and (ii) Lathyrus sativus L., known as grass pea, cicerchia, blue sweet pea, chickling pea, chickling vetch, Indian pea, white pea and white vetch, were collected from the experimental fields of the Institute of Field and Vegetable Crops in Novi Sad, Serbia. Collected samples were milled into flour using a laboratory mill. Afterwards, liposoluble compounds were extracted using n-hexane solvent and the fatty acids present were derivatized into corresponding fatty acid methyl esters in order to be analyzed on a GC-MS device (Agilent Technologies, Palo Alto, CA, USA). A HP-5MS column was used for the separation of eluting compounds and a quadrupole mass analyzer for isolating molecular ions of fatty acid methyl esters, used further as discriminating variables. Areas under the peaks were employed in further multivariate data processing by applying a hierarchical clustering tool using PAST software (Paleontological Statistics, University of Oslo, Norway). The application of the so-called 'Rho' algorithm enabled a full separation between the analyzed flour samples in two clusters/groups, according to the botanical origin: faba bean (8 samples) vs. grass pea (13 samples). A similarity/difference value of 0.2 was obtained, which directly indicates both a high level of homogeneity of liposoluble compounds within one legume species and an emphasized difference between them. Thus, it could be concluded that this semi-quantitative approach has a potential to be incorporated into standard quality control and authentication protocols of edible legume-containing items in the food market.

Key words: *legumes, flour, lipids, GC-MS, hierarchical clustering, authentication*

POLYCYCLIC AROMATIC HYDROCARBONS IN SMOKED (GRILLED) MEAT AND MEAT PRODUCTS

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) constitute a large class of organic compounds that are composed of two or more fused aromatic rings. They are primarily formed by incomplete combustion or pyrolysis of organic matter and during various industrial processes. PAHs generally occur in complex mixtures, which may consist of hundreds of compounds. Humans are exposed to PAHs by various pathways. For non-smokers the major route of exposure is consumption of food. Food can be contaminated from environmental sources, industrial food processing and from certain home cooking practices. The Scientific Committee on Food concluded that 15 PAHs, namely benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, cyclopenta[cd]pyrene, dibenz[a,h]anthracene, dibenzo[a,e]pyrene, dibenzo[a,h]pyrene, dibenzo[a,i]pyrene, dibenzo[a,l]pyrene, indeno[1,2,3-cd]pyrene, 5-methylchrysene as well as benzo[c]fluorene (in total 16 PAHs) show clear evidence of mutagenicity/genotoxicity in somatic cells in vivo and also shown clear carcinogenic effects in various types of bioassays in experimental animals. Thus, their content in food products must be controlled. European Commission (EU) Regulation setting maximum levels for PAHs in foodstuffs. According to the European Commission (EU) Regulation no. 1881/2006, 835/2011, 1327/2014 and 2020/1255, the maximum permissible concentration of benzo[a]pyrene in smoked meat and smoked meat products is 2 µg/kg and the sum of the PAH4 (benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene and chrysene) concentrations should not exceed 12 µg/kg. However, since traditional smoked meat and meat products are prone to higher levels of PAHs, a special regulation regarding PAH concentrations in such products has been issued by the Commission Regulation (EU) 2020/1255 in which the maximum benzo[a]pyrene is set to 5 µg/kg and the sum of the PAH4 (benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene and chrysene) is limited to 30 µg/kg. Among these PAH4, benzo[a]pyrene was classified in group 1 (carcinogenic to human) and the three others were classified in group 2B (possibly carcinogenic to humans) by the International Agency for Research on Cancer. Because of the high toxicity of these compounds, number of studies reported strategies for PAHs reduction. PAHs reduction strategies can be applied either before (or during) smoking (and/or grilling) – barrier methods, or after smoking (and/or grilling) – removal methods. Before smoking (and/or grilling), use of marinade, preheating of products, appropriate fuel (poor in lignin), filter, collection system of juice and fat (to avoid them dripping into embers) are the main strategies which can be applied. After smoking (and/or grilling), the methods consist of washing the surface of smoked (and/or grilled) products with hot water or storing smoked products packed into low density or high density polyethylene.

Key words: *polycyclic aromatic hydrocarbons, smoked meat and meat products, maximum levels*

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APPLICATION OF CRUDE FUNGAL LACCASE FROM *GANODERMA SPP.* IN DECOLORIZATION OF TRIPHENYLMETHANE DYE CRYSTAL VIOLET

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Abstract

Industrial dye effluents that contain triphenylmethane dyes are environment-threatening problem. The triphenylmethane dyes are one of the largest dye's group that is discharged in large quantities to water bodies. Removing of them with fungal enzymes is big scientific challenge. The fungal laccases are promising tool for removing of these dyes from water bodies. In this study, the potential of crude fungal laccase from genus Ganoderma in decolorization of triphenylmethane dye, crystal violet was investigated. The crude fungal enzyme was produced using agroindustrial lignocellulosic waste, cereal mix. The effect of different substrate masses (15g, 25g and 50 g) and Cu^{2+} ions concentrations (0.25 mM, 0.75 mM, 1.0 mM, 2.5 mM u 5.0 mM) on lccase production were investigated. The obtained crude fungal laccase with the highest activity was used for decolorization of crystal violet at different concentrations from 20 mg/L to 50 mg/L. The crude fungal laccase from genus Ganoderma had the highest activity of 47.43 U/g, when the substrate mass of 50 g was used for enzyme production. The lower masses of substrate (15g and 25g) induced lower laccase activities of 45.07 U/g and 46.69 U/g, respectively. The initial addition of Cu^{2+} ions in concentration of 0.25 mM to agroindustrial waste led to decrease of laccase activity compared to the laccase activity of laccase obtained from agroindustrial waste that didn't contain Cu^{2+} ions. On the other hand, the increase of Cu^{2+} concentration to 1.0 mM in the substrate led to increase the laccase activity. The highest laccase activity of 47.53 U/g was obtained when the 1.0 mM Cu^{2+} was added to substrate, while the decrease in laccase activity was observed when 5.0 mM Cu^{2+} was added to the agroindustrial waste. Decolorization of crystal violet at different concentrations (20 mg/L, 30 mg/L, 40 mg/L, 50 mg/L) was carred out at pH 5 and temperature of 50 ºC for 120 min. The highest decolorization efficiency of 14.42 % was obtained in the case of the lowest dye concentration (20 mg/L), while the lowest decolorization efficiency of 3.76 % was obtained when the highest dye concentration of 50 mg/L was decolorized with crude fungal laccase for 120 min. The obtained results show that fungal crude laccases can be used for decolorization of triphenylmethane dyes, but the detailed optimization is very important for obtaining relatively high decolorization efficiencies for short time.

Key words: *white rot fungi, laccase, agroindustrial waste, decolorization, triphenylmethane dye, crystal violet*

IMMOBILIZATION OF CRUDE FUNGAL LACCASE FROM *GANODERMA SPP.* ON MODIFIED TITANIUM DIOXIDE NANOPARTICLES

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Abstract

In recent decades, enzyme immobilization on different supports occupies an important place in the modern biotechnology, given that it enables the design of green and sustainable production processes. Nanoparticles are very efficient supports for enzyme immobilization. The enzyme immobilized on nanoparticles are more stable than its soluble form and can be used in several operative cycles. In this study, the potential of modified titanium dioxide nanoparticles (Degussa P25, TiO_2) for crude fungal laccase (47.43 U/g) immobilization was investigated. The TiO_2 nanoparticles were modified with (3-glycidyloxypropyl) trimetoxylane under different conditions in order to obtain support with optimal epoxy groups concentration for immobilization. The obtained TiO_2 nanoparticles had different concentrations of epoxy groups on their surface, exactly 950 µmol/g (TiO_2M1) and 500 µmol/g (TiO_2M2), respectively. The immobilization was carried out at pH 5 and at room temperature for 4 h. The residual activity of immobilized laccase on TiO_2M2 was 33.40 %, while the residual activity of immobilized laccase on TiO_2M1 was 17.39 %. The immobilization efficiency was 26.75 % and 20.18 % for laccase immobilized on TiO_2M2 and immobilized laccase on TiO_2M1, respectively. The immobilization of crude fungal laccase on TiO_2M2 was further optimized by testing the influence of different contact times between laccase and TiO_2M2 (2 h ,3 h, 3,5 h and 4 h) as well as the effect of various pH values (pH 4, pH 5 and pH 6) on immobilization. The highest residual activity of 35.04 % and immobilization efficiency of 28.95 % were obtained for optimal contact time of 3.5 h between crude fungal laccase and TiO_2M2. The lowest residual activity (30.38 %) and immobilization efficiency (20.18 %) were obtained when immobilization was carried out at room temperature and at pH 5 for 2 h. The pH values had significant effect on immobilization. The optimal pH value was pH 5 with highest residual activity of 35.04 %, while the lowest residual activity of 14. 83 % was at pH 6. The residual activity of 21.21 % and immobilization efficency of 19.52 % were obtained when crude fungal laccase immobilized at pH 4. The immobilized laccase on TiO_2M2 was successfully used in 5 cycles of guaiacol oxidation. In the 2^{nd} cycle, the immobilized laccase had residual activity of about 60%, while after 3^{rd} cycle, immobilized laccase had residual activity of 40 %. The lowest residual activity of 14.83 %, immobilized laccase had after 5^{th} cycle.

Key words: *laccase, immobilization, white rot fungi, titanium dioxide nanoparticles*

CADMIUM AND LEAD IN THE MEAT AND EDIBLE OFFAL – MAXIMUM LEVELS ACCORDING TO NEW EUROPEAN UNION REGULATIONS

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Abstract

Metals such as cadmium and lead are naturally occurring chemical compounds. They can be present at various levels in the environment, e.g. soil, water and atmosphere. These metals can also occur as contaminants in food because of their presence in the environment, as a result of human activities, such as farming, industry or car exhausts or from contamination during food processing and storage. People can be exposed to these metals from the environment or by ingesting contaminated food or water. Their accumulation in the body can lead to harmful effects over time. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals Because of their high degree of toxicity, cadmium and lead rank among the priority metals that are of public health significance. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure. They are also classified as human carcinogens (known or probable) according to the International Agency for Research on Cancer. The EFSA panel on contaminants in the food chain established a tolerable weekly intake (TWI) for cadmium and lead of 2.5 and 25 μg kg^{-1} body weight, respectively. The European Union has recently set new maximum levels – MLs (Table 1) for cadmium and lead in certain foodstuffs (meat and offal) based on produce class and expressed as wet weight (Commission Regulations (EU) 2021/1323 and (EU) 2021/1317).

Table 1. Cadmium and lead maximum levels (mg/kg wet weight) in meat and edible offal

Toxic metal	*Standard*	*Meat and edible offal*	*MLs*
Cadmium	*Commission Regulation (EU) 2021/1323*	*Meat (excluding offal) of bovine animals, sheep, pig and poultry*	*0.05*
		Horsemeat, excluding offal	*0.20*
		Liver of bovine animals, sheep, pig poultry and horse	*0.50*
		Kidney of bovine animals, sheep, pig, poultry and horse	*1.0*
Lead	*Commission Regulation (EU) 2021/1317*	*Meat (excluding offal) of bovine animals, sheep, pig and poultry*	*0.10*
		Offal of bovine animals and sheep	*0.20*
		Offal of pig	*0.15*
		Offal of poultry	*0.10*

These new regulations have significantly reduced the maximum tolerable levels for lead in offal.

Key words: *cadmium, lead, meat, offal*

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MICROBIOLOGICAL AND CHEMICAL QUALITY OF LYOPHILIZED AND LIQUID GOAT WHEY ON SERBIAN MARKET

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Abstract

Recent years, the global dairy goat industry is expanding rapidly, as well as its derived products. In Serbia, there has been noticed increasing demand for liquid goat whey during last several years. Mainly, in Serbian market liquid goat whey generally originated from small goat farms or cheese factories, while lyophilized goat whey is also present in markets and as far as we know there are present only two producers. The main difference between goat whey produced from small goat farms and dairy producers is in Regulation of the Republic of Serbia, where small goat farms have milder legal requirements. Since Serbian legislation has few requirements with goat whey, the aim of this study was to determine microbiological and chemical quality of liquid and lyophilized goat whey samples from Serbian market. Totally 10 samples were collected, out of which 4 whey samples were produced on farm, 4 samples in dairy factory and 2 samples were lyophilized. Count of coagulase positive staphylococci was determined according to the EN ISO 6888-2, while Escherichia coli was examined with ISO 16649-2 and Listeria monocytogenes according to EN ISO 11290-2. Chemical composition of goat whey samples included determination of dry matter content, fat and protein content using the FIL-IDF methods. The count of coagulase positive staphylococci was in the range between 3.03-5.49 log cfu/ml which is in agreement with the Regulation of food hygiene of Serbia, while E. coli and L. monocytogenes weren't detected. The obtained results showed that dry matter content of liquid goat whey samples was in agreement with the Regulation of ordinance on quality of milk and starter cultures and it was between 5.68-7.4%. Lyophilized samples had lower dry matter content 2.72 and 3.01%, which is also in accordance with Regulation. The fat content was in the range 0.1-1.15% for all samples. Likewise, total protein content was in the range between 0.44-1.02%, while lyophilized samples had 0.23-0.38% of protein. Obtained results showed that there were no significant difference between goat whey from small farms and dairy factory. Overall, microbiological and chemical quality of liquid goat whey samples, as well as lyophilized, was at satisfactory level.

Key words: *goat whey, microbiological quality, chemical quality, regulation*

DYEING OF COTTON FABRIC WITH UNCONVENTIONAL DYE

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Abstract

*Unconventional dye, such as salicylaldehyde-phenylhydrazone (previously synthesized in a crude glycerol, by aldol-condensation reaction between salicylaldehyde and phenylhydrazine) was used for dyeing of cotton fabric. Cotton is one of the oldest natural fibers. This fiber has many advantages: absorbs moisture very well, has a pleasant feel, does not cause allergies, excellent thermal insulation properties etc. Cotton is the cleanest cellulose fabric, which contains 95-98% α-cellulose and lower lignin content. Dyeing of cotton is one of the most important technological procedures in the production of cotton products. Cotton is dyed in an aqueous solution under alkaline conditions using different classes of dyes. The most important for cotton dyeing are reactive, direct and reductive dyes. When dyeing textile materials, it is important to achieve the desired shade with the greatest possible use of colors. This is important not only for economic reasons, but also for environmental reasons, because with a high degree of exhaustion, the residual dye in the solution that reaches watercourses and pollutes the environment is minimized, which has a positive impact on environmental protection. The used concentrations of dye were 0.5, 1 and 2.5%. The temperature of dyeing was 60 °C. The ratio of the dye bath was 50:1. The equilibrium time of dyeing was 60 minutes. All used concentrations showed very good substantively for cotton fibers with good dyeing performance according to CIEL*a*b* parameters. The results are in accordance to salicylaldehyde-phenylhydrazone chemical structure, since dye possess, the most important chromophore azomethine (HC=N) and carbonyl (C=O), as well as, hydroxyl (OH) group in orto-position. The highest difference in total colour value was obtained for dyed cotton sample with salicylaldehyde-phenylhydrazone in concentration of 2.5%. The cotton fabric is lighter, more saturated and more blue, when it is dyed with 0.5%. Also, dyed cotton sample was darker, more saturated and more blue when it is dyed with 1.0%.*

Key words: *cotton fabric, dyeing, CIEL*a*b*, unconventional dye*

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APPLICATION OF ALUMINA-SUPPORTED COOPER CATALYST PELLET ON ESTERIFICATION OF LACTIC ACID WITH 1-BUTANOL

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Abstract

Esterification of lactic acid with lower alcohol in the presence of solid catalysts has been widely used in production of lactate esters, which are generally considered as green solvents with broad range of application including flavor, fragrance, and pharmaceutical industries. The reaction has also recently gained more attention as a practical mean to transform low volatile lactic acid (boiling point of 122 °C at 15 mmHg) into its more volatile ester. The technique facilitates separation and purification of lactic acid in reactive distillation, where the ester is hydrolyzed back into lactic acid after it is evaporated out from other components. The challenge lies in the fact that lactic acid esterification is reversible and slow by nature. As a result, effective catalysts are needed to drive the reaction equilibrium forward and increase the reaction yield. For large scale production, inexpensive catalysts are crucially desirable in order to keep the process at economical level. In this work, alumina-supported copper catalyst pellets were prepared and tested for its performance in lactic acid esterification. Porous γ-alumina pellets with BET surface area of 175 m^2/g were used as catalyst support, and copper (II) sulfate was used as the catalyst precursor. Effect of copper sulfate concentration and adsorption time on activity of the prepared catalyst was evaluated. Surface properties of the pellets were determined using Brunauer-Emmett-Teller (BET) with N_2 adsorption. Crystal structure, copper loading were analyzed by X-ray powder diffractometer (XRD), scanning electron microscope equipped with the energy dispersive X-ray spectrometer (SEM-EDX), while total acidity of the catalyst was measured by Boehm titration method. The prepared catalyst pellets came with surface area in the range of 95.57-123.72 m^2/g, copper content between 5.23-8.32% and total acidity between 1.85-2.35 mmol/g. Increasing copper content led to decreasing BET surface area but increasing acidity of the prepared catalyst. The catalyst performance and stability in esterification of lactic acid with 1-butanol in batch reactor were studied. Lactic acid conversion after 360 min of reaction time, 1 %wt/v of catalyst concentration and 75 °C of reaction temperature ranged between 32.36%-47.20% depending on the catalyst's acidity. The highest conversion was obtained from the catalyst prepared with 1.50 mol/dm^3 precursor solution and 120 min adsorption time. This catalyst lost its activity upon repetetive usage for three times resulting in reduced lactic acid conversion from 46.73% to 32.49% and to 23.02%.

***Key words**: Copper catalyst, Esterification, Lactic acid, 1-Butanol*

EFFECT OF STARCH CONTENT AND CALCINATION TEMPERATURE ON PREPARATION OF POROUS γ-ALUMINA BY STARCH CONSOLIDATION CASTING TECHNIQUE

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Abstract

Aluminum oxide or alumina (Al_2O_3) is an important compound in material science research and application. This material can be found in different forms depending on sources and method of preparation. The most stable form is α-Al_2O_3 (Corundum), which is employed as a ceramic material, and is characterized by its high crystallinity and octahedral coordination of aluminum. Another widely utilized form is γ- Al_2O_3, which is mostly used in catalysis and adsorption due to its high surface area and porosity as well as good thermal stability that allowing the application in up to 700 ºC. Porous γ-alumina is particularly used as a catalyst carrier due to its chemical properties. These properties are strongly correlated with the physical properties of the material, such as porosity, density, shrinkage, and surface area, which are directly related to the methods used for synthesis of the material. In this work, the bimodal porous γ-alumina was synthesized by starch consolidation casting technique (SCC). Commercially available boehmite (Pural SB, Sasol), food grade cassava starch, polyethylene glycol with molecular weight of 8000 (PEG8000), as well as Pluronic P123, a copolymer of poly(ethylene oxide) (PEO) and poly(propylene oxide) (PPO), were used as alumina precursor, pore forming agent and dispersant agent, respectively. Effect of cassava starch content and calcination temperature to bimodal porous γ-alumina properties was studied. The surface properties and crystalline structure of bimodal porous γ-alumina pellet were analyzed using Brunauer-Emmett-Teller (BET) with N_2 adsorption and X-ray diffraction (XRD) analysis. The 3D structure, macropore distribution and porosity were investigated by synchrotron radiation X-ray tomographic microscopy (XTM). The prepared bimodal porous γ-alumina pellet was found to have BET surface area in the range of 161–218 m^2/g, the average pore size diameter in mesopore range of 10 nm, the interconnected macropore size of 62.65–259.86 μm, and the open porosity around 5.01–22.30%. Utilizing commercially and redundantly available cassava starch in preparation of γ-alumina could help lowering the production cost of this material.

Key words: *Porous γ-alumina, Aluminum oxide, Starch consolidation casting, Mesopore, Cassava starch*

MONITORING THE GLAZING PROCESS IN FROZEN FISH. A PRACTICAL CASE

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Abstract

Glazing is a processing step widely used in frozen fish and is one of the critical points in its processing. The present work aimed to evaluate the fish glazing process in a frozen fish processing enterprise. Mean and Range Control Charts, one of the tools of statistical quality control, were used to check whether the process was statistically controlled. The method used to determine the percentage of glazing water was the Portuguese legislation Decreto-Lei n.º 37/2004. The percentage of glazing water before the tunnel and at the end of the glazing process was also determined and compared for two groups of fish, one group when the fish is cut into slices or fillets (ling, plaice, salmon, skate, hake fillet, Argentine hake slices to be fried, Argentine hake slices to be boiled, 5 Chile hake slices to be boiled, South African hake slices to be boiled) and another group of frozen whole fish (sardines, petinga, pota, Argentine hake 0, Argentine hake 1, redfish M and redfish L). It was possible to establish the control limits for the Control Charts of Mean and Range for three fishes: ling, sardine, and salmon. These charts were implemented in the production line and the process was found to be statistically controlled. Regarding the gains from the glazing water, it was observed that for each type of fish there were distinct tendencies. In the first group (fish slices/ fillet) the hake fillet was the one with the highest percentage of glazing water at the end of the glazing process, with an average value of 33.0%, while the Southern African hake slices to be boiled had the lowest value of 12.0%. In the case of the second group (whole fish) petinga was the fish that showed the highest percentage of glazing water at the end of the glazing process, with an average value of 27.2%, while hake 1 showed the lowest average value of glazing water, 12.8%. Since the percentage of glazing water has legal limits and given the variability observed in the fish studied, it is evident that constant monitoring of the glazing process is fundamental, becoming an added value for the company.

Key words: *fish, freezing, glazing water, process monitoring.*

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UNDERSTANDING MECHANISMS AND KINETICS IN HETEROGENEOUS CATALYSIS USING MULTISCALE MODELLING

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Abstract

The chemical industry is highly dependent on catalysis, as the vast majority of chemical reactions occur in the presence of at least one catalyst. Heterogeneous catalysis is often preferred because it allows easy separation of products and catalysts and can be integrated into continuous processes. Catalysts play a critical role in reducing the energy required for chemical reactions.

In the past, catalysts were discovered primarily through experimentation and observation. Although empirical relationships have been established, a comprehensive understanding of their operation has not been achieved. Research in chemical engineering and catalyst design has accumulated a wealth of data, but a comprehensive understanding has been lacking. However, with advances in computational power and tools in recent years, it has become possible to intelligently design catalysts and optimize processes.

Multiscale modelling has become a leading approach to modelling catalytic processes. Any catalytic process can be described at different scales, from the atomic level to mass and heat transfer in large reactors. It is not possible to describe the process using a single method, but different approaches can be combined in a multiscale description. With multiscale modelling, it is possible to describe the reaction from the basic principles to the reactor level, using simplifications and abstractions only when necessary. This leads to the creation of digital twins that allow computer-aided optimization of reaction conditions. In addition, insights and modelling based on fundamental principles can enable catalyst discovery and targeted synthesis.

In this talk, we will present four different practical cases where multiscale modelling was indispensable for understanding the experimental data: (i) nitration of methylcatechols, (ii) CO_2 activation on CeO_2, (iii) CO_2 reduction on a bifunctional catalyst and (iv) catalyst screening for ethylene epoxidation. We will cover the roles of DFT, KMC, microkinetic modelling and CFD simulations. In (i), DFT calculations were performed to elucidate the potential energy surface, showing which site in methylcatechols is must susceptible to an electrophilic attack. The site with the lowest barrier was later confirmed the experiments to undergo nitration. In (ii), DFT simulations were performed to elucidate the adsorption modes of CO_2. Three different adsorption modes were discovered, which were then confirmed with TPD experiments. DFT studies were complemented with KMC simulations in (iii), where a role of two phases in a bifunctional catalyst was discovered. Using KMC simulations, the kinetic contributions of individual phases (copper, perovskite, interface) were identified. In (iv), a full fledged DFT+KMC+CFD study was performed, both explaining the performance of a silver catalyst for ethylene epoxidation in a real reactor and steering us towards a better catalyst in a periodic table screening.

Key words: *multiscale modelling, heterogeneous catalysis, DFT, KMC*

EXPERIMENTAL STUDY OF THE PERFORMANCE OF AN OPEN-TYPE REFRIGERATED DISPLAY CABINET

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Abstract

The open-type multi-deck refrigerated display cabinets became very common in retail food stores as promo refrigerators. They attract customers because there is no physical barrier between them and the food products. However, open-type refrigerated cabinets are less energy-effective than closed refrigerated cabinets. This causes additional sufficient expenses, also considering the fact that the price of electricity is constantly increasing. The purpose of the study was to increase the efficiency of the open-type cabinet by improving its design. The open-type vertical refrigerated display cabinet used to store food at temperatures between -1 and +7 °C was chosen as research object. The overall dimensions of the cabinet (W·D·H) are the following: 2500·970·1460 mm. The cabinet has 5 shelves for food products with depths ranging from 350 to 600 mm. The spacing between the base and the first shelf is 280 mm, between the other shelves is 250 mm. A summary of the refrigerated cabinet working principle can be presented as follows: air enters the cabinet from the air grill attached to the front of the bottom panel, fans blow air through the evaporator, and cooled air travels through a tunnel to the top of the refrigerator. The perforated distributor at the top distributes the cooled air and part of the air is directed through the perforated back panel, and the other part passes through the air-off honeycomb installed at the front top of the cabinet, thus forming an air curtain between the inside of the refrigerator and the ambient warm air to protect the chilled food products. The air cooled entering through the perforated back panel into the display area helps to maintain the required food temperature. The honeycomb dimensions (W·H) are 120·20 mm. In the study, two versions of refrigerated cabinets were analyzed. The first version is the standard refrigeration cabinet and the second version was the same cabinet but with changed the inclination angle of the honeycomb and reduced the depth of the shelves. The temperatures of air and test food products were measured with thermocouples and a hot wire anemometer, and the electrical energy consumption was measured with the Carel MT300W1100 energy meter. In summary, the following conclusions can be drawn:

- *The infiltration ratio decreases from 38.7% to 27.7% in the improved version of the cabinet.*
- *Electrical consumption at 24 hours decreases from 24.91 to 19.22 kWh.*
- *The average temperature in the return air grille decreases from 7.5 to 6.5°C with the same temperature settings. The average temperature in the honeycomb shows that the modified version requires less energy to maintain the temperature in the refrigerated cabinet.*
- *The average temperature of the M packets decreases from 0.2 to 2.2 °C depending on the position of the packet.*

Key words: *open-type refrigerated display cabinet, air curtain, honeycomb, heat transfer, air temperature, energy consumption*

SPRAY DRYING OF MANDARIN PEEL EXTRACT OBTAINED BY ULTRASONIC PROBE

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Abstract

Citrus fruits, which belong to the Rutaceae family, play an important part in the food-processing industry and agro-industrial sector. They are considered as one of the most commonly cultivated and consumed fruits all over the world. Citrus peel forms around 40–50% of the total fruit mass, but is generally disposed as waste. During the last decade, there has been a continuous growth in consumption and global marketing of fresh, easy-to-peel mandarins, with current annual production of nearly 29 million tons. Mandarin peel (Citrus unshiu var. Okitsu) is abundant in flavonoids and carotenoids, but is also underutilized as rest of the citrus fruits. In order to recover flavonoids from mandarin peel, green extraction technology, ultrasound assisted extraction with ultrasonic probe (UAE-P), was used instead of conventional solid/liquid extraction. The study was divided into two phases: (a) the first part of experiments was related to UAE-P of lyophilized mandarin peel, and (b) in the second part of experiment the UAE mandarin peel extract was spray dried. For UAE-P, aqueous ethanol solution (70%) was used as a solvent in solid/liquid ratio of 1:10 (w/v). The amplitude level was kept 40%, while extraction lasted until temperature reached 40 °C. Prior to spray drying, the obtained liquid extract was vacuum dried to reduce the volume for 30% in order to decrease the alcohol content. The inlet temperature was set at 120 °C. The spray drying of UAE extract was carried out with addition of carrier, 30% maltodextrin 8.3 DE, calculated in respect to dry matter. The powder was physically characterized (moisture content, hygroscopicity, water absorption and water solubility indices, bulk density) and total phenols (28.84 mg GAE/g dry extract) and total flavonoids (2.39 mg CE/g dry extract) were determined spectrophotometrically to evaluate its potential application in food industry. According to obtained results, mandarin peel dry extract could be used as a natural preservative and colorant in bakery products.

Key words: *mandarin peel, ultrasound extraction, spray drying, polyphenols.*

PYROLYSIS OF WOOD-BASED BLACK LIQUOR, AS AN EFFICIENT PROCESS FOR THE PRODUCTION OF ALTERNATIVE FUELS

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Abstract

Lignocellulosic biomass is produced worldwide in large quantities, which leads to acute environmental change, global warming, wildfires, rising ocean and sea levels. Recent research has attempted to utilize the reconversion of black liquor into biohydrogen, biogas, and CO_2-selective absorbent materials through the pyrolysis process. Following the pyrolysis process of the black liquid which is considered a toxic product, the following components are distinguished: bio-oil, synthesis gas and biochar. The synthesis gas developed as a result of the pyrolysis process can be used for energy purposes not before being passed through a specific process of filtering/purifying/eliminating/retaining the N_2 and CO_2 content. Also, in order to increase the energy values of synthesis gas, as well as to reduce the negative impact on the environment, it is desirable to be used in mixtures, in different ratios, with natural gas, geothermal gas, biogas, etc. Bio-oil can be used as an alternative fuel for fossil fuels after refining. Bio-char, black in color and with a specific smell of H_2S, can be used as an adsorbent after an activation process for CO_2 capture and storage. Pyrolysis can be considered an environmentally friendly process, as it reduces the emission of greenhouse gases, while heavy metals are retained in the final residue. The advantages of pyrolysis of black liquor were presented in this paper. The products obtained from BL pyrolysis can be used as raw material in industry because they are energy efficient. Chemical composition has an important role in lignocellulosic black liquor, this chemical composition of the substrate determining its fate for further processing or utilization.

Key words: *lignin, black liquor, pyrolysis, syngas, bio-oil, bio-char*

RAMAN SPECTROSCOPY APPLIED TO BIOBASED MINERAL FERTILIZERS

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Abstract

The anaerobic digestion process has been applied to valorize the livestock slurry, since it provides biogas as a renewable energy. At the end of the process the sludge obtained, called the digestate, has still fertilizer value. The digestate contains stable organic matter and several crop nutrients namely N, P and K. However, their mineral composition and the availability of the crop nutrients changed between animal species. So, to have a more concentrated and known mineral composition it's possible to extract some nutrients from the digestates allowing to obtain biobased mineral fertilizers. In this case, the gas-permeable membrane technology to capture N from co-digested slurry with orange peel residue was used to recover the N from the digestate, obtaining a liquid solution of ammonium sulfate (ASS). These biobased mineral fertilizers have proved to have the same or even higher agronomic value than the traditional mineral fertilizers which are obtained from the exploitation of nonrenewable natural resources. The aim of this work was i) to test the Raman spectroscopy to early access the composition of biobased fertilizers obtained in liquid form and ii) evaluate the ability of this spectroscopic technic to discriminate between the fertilizers obtained from different sources. The liquid solution of ammonium sulfate (ASS) together with a half-strength Hoagland solution and a half-strength Hoagland solution without N were tested.
Fourier Transform Raman Spectroscopy (FT-RAMAN) with a Ge Diode detector and a Nd:YAG laser with a maximum output power of 500 mW, were used to analyze the aforementioned described samples. The spectra were collected with 100 scans per spectrum at a spectral resolution of 4 cm^{-1} (in the wavenumber range from 4000 to 200 cm^{-1}) in a quartz cell of 5 mm of optic space. The results show that the more relevant spectral region to analyze the functional groups with relevance for this study is situated from 1700 cm^{-1} to 750 cm^{-1}. At this region it is possible to observe the influence of O-H and N-H bonds, vibration of COO- group, bending vibration of C–H, C–O–H, C–N bond, the influence of the C–O–C and C–N vibration and C–Cl linking's. All this information allowed to discriminate the samples solution by spectral analysis and by principal component analyses performed with spectra.

Key words: *Slurry; Digestate, Nitrogen recovery, FT-RAMAN*

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TRACE-ELEMENTAL PROFILING OF LEGUME SPECIES CONVENTIONALLY GROWN IN SERBIA

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Abstract

Legume samples belonging to the following species: beans (Phaseouls vulgaris; 9), green beans (Phaseolus vulgaris; 4), mountain beans (Phaseolus coccineus; 3), faba beans (Vicia faba; 8), peas (Pisum sativum; 7) and grass pea (Lathirys sativus; 6), were analyzed in this study. Samples were grown conventionally at the experimental fields of the Institute of Field and Vegetable Crops during 2019. They were digested in a microwave oven (Speedwave S/N00386, Berghof, Eningen, Germany), following a slightly modified and shortened method compared to the method for cereal grain samples provided by the manufacturer. About 0.5 g (± 2%) of each flour sample was put in a teflon vessel, where 5 ml of 65% nitric acid and 2 ml of 30% hydrogen peroxide were added. The microwave power was 800 W, with a total digestion time of 40 minutes, with additional 20 minutes for cooling down the sample vessels to room temperature. A clear liquid obtained after digesting each sample was diluted with a 2% nitric acid and put in a vial for further analysis on an ICP-OES device (Optima 8300, Perkin Elmer), in order to perform trace element screening (cadmium Cd 228.8 nm, lead Pb 220.3 nm, nickel Ni 231.6 nm, chromium Cr 267.7 nm, and arsenic As 188.9 nm). The elemental composition was obtained in the form ml per L, but converted to mg per kg of flour sample. All samples were analyzed in triplicate. Summary statistics, MANOVA and PCA were performed using an open-source software PAST 4.07b (Natural History Museum, University of Oslo, Norway). The contents of the analyzed trace elements were as follows: Cd (0.04 ± 0.06), Pb (0.63 ± 0.47), Ni (36.23 ± 11.89), Cr (3.02 ± 6.42), and As (0.02 ± 0.11). Shapiro-Wilk's test demonstrated a significant deviation from a normal distribution and the summary statistics showed very high deviation of trace elemental content between analyzed samples. MANOVA showed non-significant differences between groups, i.e. legume species, and PCA analysis revealed distribution patterns of trace elements between investigated legumes. Comparing the results with the Rule book on maximum concentrations of certain contaminants in food („Sl. glasnik RS", no. 81/2019, 126/2020 and 90/2021) which is defining the maximal values for Cd (<0.20), Pb (<0.20) and As (<0.20) in cereal and legume samples, it can be concluded that the samples of tested legumes in many cases exceed the permitted levels, indicating whether soil, water or air as sources of pollution in the growing area.

Key words: *trace elements, legumes, flour, microwave digestion, ICP-OES, profiling*

THE STABILITY OF LIPOSOMES WITH ERGOSTEROL AND *THYMUS SERPYLLUM* L. EXTRACT

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Abstract

Thymus serpyllum L. contains biologically active components, such as essential oil, polyphenols (flavonoids, phenolic acids, and anthocyanins), monoterpenes, polysaccharides, and proteins. Nevertheless, the use of the mentioned substances is rather limited, due to their low bioavailability, integrity, permeability, solubility, and stability. Therefore, their encapsulation in the liposomal particles can be advantageous. Apart from phospholipids, the addition of sterols during liposomal preparation can improve the physicochemical properties of the obtained particles. Thus, in the present study, ergosterol (10 and 20 mol %) and T. serpyllum extract loaded liposomes were developed. Vesicle size, polydispersity index (PDI), zeta potential, conductivity, and mobility of the obtained liposomes were determined using photon correlation spectroscopy. Additionally, the storage stability of the liposomes at 4ºC was investigated for 21 days. The liposomes with T. serpyllum extract were smaller than unloaded liposomes, while with the increase of ergosterol content vesicle size increased in all liposomes. The addition of extract caused the increase in the PDI, while it did not influence zeta potential. A phospholipid bilayer with 10 mol % of ergosterol possessed higher zeta potential (absolute value), conductivity, and mobility than a membrane containing 20 mol % of ergosterol. The vesicle sizes of all liposomes did not change drastically during 21 days of storage, whereas a slight increase of PDI appeared in extract loaded-liposomes after the 14th day. The zeta potential and mobility varied in all liposomes, and the trend depended on the composition of the membrane and the absence or the presence of the extract. The conductivity of the liposomes did not change during 21 days, except in the case of unloaded liposomes with 10 mol % ergosterol. The beneficial effects of polyphenols and ergosterol on human health highlight the use of the liposomes with ergosterol and T. serpyllum L. extract for potential application in foods, pharmaceutics, and cosmetics.

Key words: *ergosterol, liposomes, polyphenols, stability, Thymus serpyllum*

ULTRASOUND-ASSISTED EXTRACTION OF *ROSA CANINA* L. USING NATURAL DEEP EUTECTIC SOLVENTS

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Abstract

Rosa canina L. (Rosaceae) is frequently employed in traditional medicine, due to its diuretic, anti-inflammatory, anti-allergic, antioxidant, and analgesic properties. The ultrasound-assisted extraction is frequently used as an extraction technique, due to the increased extraction yield, improved extract quality, fast kinetics, and simple operation. Additionally, in recent times, natural deep eutectic solvents (NADESs) are applied as a tool for improving polyphenol recovery from various plant materials. Thus, in the present study, R. canina extracts were prepared using dried rose hips (0.25 g), two types of natural deep eutectic solvents (25 mL, choline chloride+citric acid with 50% of water and betaine+citric acid with 70% of water), and ultrasound probe (40% amplitude for 10 min). The extracts were characterized via analyzing total polyphenol content (TPC), antioxidant potential (ABTS and DPPH assays), extraction yield, pH, zeta potential, conductivity, density, surface tension, and viscosity. TPC of choline chloride+citric acid and betaine+citric acid extracts were 8.75±0.17 and 7.47±0.04 mg gallic acid equivalents (GAE)/g of plant material, respectively. ABTS radical scavenging activity was 3.03±0.62 mmol Trolox/g of plant material (choline chloride+citric acid extract) and 2.82±0.13 mmol Trolox/g (betaine+citric acid extract), whereas, in DPPH assay, IC_{50} was 1.02±0.04 mg/mL for choline chloride+citric acid extract and 1.98±0.10 mg/mL for betaine+citric acid extract. The extraction yield was 0.575±0.035% (choline chloride+citric acid extract), and 0.490±0.016% (betaine+citric acid extract). pH values for chloride+citric acid and betaine+citric acid extracts were 0.83±0.03 and 2.68±0.02, while zeta potential was 2.46±0.16 and 0.88±0.09 mV, respectively. Conductivity for chloride+citric acid and betaine+citric acid extracts were 35.8±0.4 and 4.3±0.3 mS/cm, density was 1.16±0.01 and 1.54±0.02 g/mL, while surface tension was 35.2±0.8 and 37.2±0.1 mN/m, respectively. Viscosity was 6.52±0.01 mPa•s (choline chloride+citric acid extract) and 5.14±0.12 mPa•s (betaine+citric acid extract). Due to higher TPC and DPPH radical scavenging capacity, R. canina extract prepared using choline chloride and citric acid with 50% water in comparison to betaine+citric acid extract was favored as an ingredient in food, pharmaceutical, and cosmetic products.

Key words: *antioxidant activity, natural deep eutectic solvent, polyphenols, Rosa canina, viscosity*

HETEROGENISATION OF THE ADIPIC ACID PRODUCTION FROM BIORENEWABLES USING A RHENIUM CATALYST

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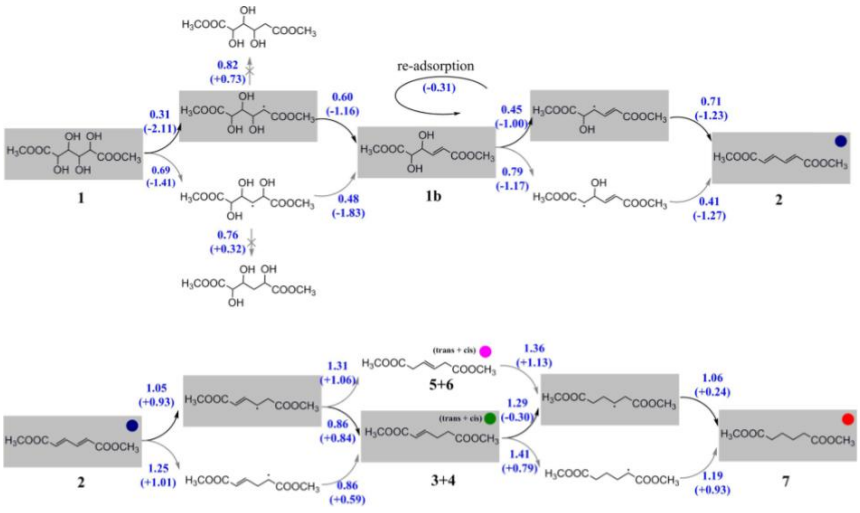
Abstract

In this conference paper, we report on the sustainable catalytic system we have developed to produce adipic acid from biobased aldaric acids. Adipic acid is the most important dicarboxylic acid with a market of over $7 billion. Currently, it is produced with low sales from fossil sources (crude oil-based cyclohexane) using corrosive nitric acid and emitting NO_x. A sustainable production route from biobased lignocellulosic biomass has been proposed, but has so far only succeeded with homogeneous catalysts and with low yields.
We have successfully demonstrated selective (93 %) dehydroxylation of aldaric acids using a heterogeneous catalyst without the need for gaseous H_2 or corrosive HBr reactants. This is the first time that this has been accomplished. Our main results show that it is possible to use a heterogeneous catalyst for the selective dehydroxylation of aldaric acids, allowing continuous operation in a fixed-bed reactor and facilitating the separation of the product and the regeneration of the catalyst.
Our research shows that rhenium (Re) is the only useful catalytically active metal, and it is only effective when used on a neutral carbon support. This was determined after we tested more than 20 other combinations. We also showed that hydrogen is not required for dehydroxylation and subsequent hydrogenation, and that any short-chain alcohol can serve as a hydrogen donor. Unlike Rennovia's patented process, this is a unique achievement as no corrosive solvents are required. High yields and high selectivity of the dehydroxylation products were obtained even at 120 °C. Detailed characterization and extensive DFT studies showed that the metallic Re sequentially removes OH groups and preferentially uses methanol as a hydrogen source.



Key words: *heterogeneous catalysis, adipic acid, production, rhenium*

THEORETICAL BIOGAS POTENTIAL PREDICTION FROM ORGANIC FRACTION OF MUNICIPAL WASTE IN BANJA LUKA REGION

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Abstract

In the Banja Luka region (Republic of Srpska/Bosnia and Herzegovina) dominant fraction in municipal waste is the organic fraction (>40%). The organic fraction of municipal solid waste (OFMSW) consists of kitchen waste from households and restaurants, and garden and park waste. All collected waste is disposed of in the regional landfill in Banja Luka. OFMSW is a part of biomass (biowaste) that has the potential as a feedstock for anaerobic digestion. Anaerobic digestion implies the degradation of OFMSW, including the generation of methane-rich biogas. Produced biogas is a renewable energy source that can replace conventional fuels to generate electricity and heat or can be converted to fuel by upgrading it. Recent studies show that biogas produced by anaerobic digestion provides significant advantages over other forms of bioenergy as anaerobic digestion presents energy-efficient and environmentally friendly technology. The potential of biogas generated from waste is influenced by process parameters (organic loading rate, C/N ratio, pH, temperature, moisture content, and retention time), the chemical characteristics of the waste (pH, total solids, volatile solids, Kjeldahl nitrogen), as well as elemental composition of the waste (C, H, O, N, S). This study predicts biogas potential based on data on the elemental composition of the waste and uses a simplistic model to define the theoretical amount of biogas that can be generated from OFMSW. The obtained value of theoretical biochemical methane potential (TBMP) calculated by Boyle's formula is 398 ml CH4/g volatile solids. Besides the biogas potential for energy production, the benefits of anaerobic digestion of OFMSW are multiple considering environmental aspects: reduction of waste disposal, organic waste treatment, reduction of greenhouse gas emissions and water pollution reduction, green energy production, increasing resource efficiency, etc. The results of this theoretical study can be a driver for further research of biogas potential from waste with the aim to establish sustainable waste management in the Banja Luka region.

Key words: *organic fraction of municipal solid waste, anaerobic digestion, biogas, sustainable waste management*

DETERMINATION OF TOTAL POLAR COMPOUNDS IN SUNFLOWER OIL AFTER ADSORPTION ON ALUMOSILICATES

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Abstract

By heating the oil at higher temperatures, various chemical reactions take place, causing changes in the quality parameters of the oil. The content of total polar compounds (TPC) is an indicator of the presence of oxidation degradation products in the oil. In this paper, the content of TPC was determined after heating the oil at a temperature of 110°C to 190°C for 10 minutes. It was found that by heating the TPC content increases from 3.5% to 5.5%. After that, the possibility of oil regeneration by adsorption on aluminosilicates (zeolite 4A, clinoptilolite and bentonite) was investigated. It was found that in oil heated for 10 minutes, the content of TPC decreased in all three adsorbents by 45%, 36% and 27% successively. Based on the obtained test results and with the aim of examining the reuse of oil or the possibility of its use for other purposes as well as the protection of human health and the environment, it would be good to continue research in the direction of determining other parameters of thermal degradation.

Key words: *total polar substances, sunflower oil, aluminosilicates*

ATOMISTICA.ONLINE – MOLECULAR MODELING PLATFORM FOR RESEARCH AND TEACHING IN MATERIALS SCIENCE

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Abstract

Computational modeling of molecules and periodic structures has become an indispensable tool for developing new materials. Atomistic calculations are one of the cores of computational materials modeling since they allow an understanding of different properties of matter at the atomic level. These calculations rely on various methods, including both quantum-mechanical and classical approaches. In the last 15 years, we have witnessed an enormous development in applying these methods to design and develop novel materials.
The scientific community has many computational tools for atomistic calculations on molecules, including commercial, open-source, or free-for-academic tools. Even though numerous modeling codes are free, it doesn't mean they are less powerful than some commercial codes. On the contrary, certain free-for-academic modeling codes are, in many aspects, at least comparable with commercial modeling codes, while in many aspects, they even outperform. However, commercial software solutions offer outstanding code optimization, graphical user interfaces and postprocessing tools, making molecular modeling a pleasant experience. Free tools for working with various molecular modeling codes are available. However, these tools are rarely available online, imposing the necessity to install and maintain software.
To bridge the gap for beginners in molecular modeling, we have developed atomistica.online – molecular modeling platform containing a set of web applications for generating input files, calculating properties, and even performing semiempirical calculations. All the tools from atomistica.online are freely available at https://atomistica.online; they are used directly in a web browser without needing to install or maintain anything, making them suitable for teaching as well. Atomistica.online has been created mainly using the python programming language and the Anvil platform (https://anvil.works).
Currently, the essential tools of the atomistica.online are an input generator for the ORCA modeling package, detonation properties calculator, ADME calculator, and applications for running online semiempirical calculations with xtb and MOPAC2016 programs. The next steps in the further technical development of atomistica.online will include developing applications for generating input files for the PSI4 program and analyzing output files generated by different molecular modeling codes.

Key words: *Molecular modeling, atomistic calculations, input generator, python, Anvil*

RISK ANALYSIS OF PRESENCE OF AFLATOXIN M1 IN PRODUCTION CHAIN OF MILK PRODUCTS

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Abstract

The risk of the presence of aflatoxin M1 in milk products was analysed in this paper. Milk and milk products are very important in the human diet, as they are significant sources of calcium. They also contain very important nutrients, such as proteins, vitamins B1, B2, B12, and A and D vitamins.

Aflatoxins are toxic, mutagenic, teratogenic and carcinogenic compounds. Contamination with aflatoxins occurs through the direct intake of contaminated agricultural products, or indirectly through the consumption of products of animal origin prepared or obtained from animals that were fed with contaminated food. When ingested, they cause damage to the liver and other internal organs. They have an inhibitory effect on the replication of DNA, RNA and protein synthesis. Aflatoxin M1 is a 4-hydroxyl derivative of aflatoxin B1. It is synthesized in the ruminant organism after eating food contaminated with aflatoxin B1, and it can be found in milk and milk products.

The amount of aflatoxin M1, which can be found in milk products and cause fatal consequences, depends on the applied agrotechnical measures, as well as on the production, packaging and storage processes. Aflatoxin M1 is identified in milk 12-24 hours after consuming food contaminated with aflatoxin B1. In cheese made from milk contaminated with aflatoxin B1, the amount of aflatoxin M1 is higher in the final product, compared to the amount found in milk. The consequence of this is due to the method of production and the specificity of the production process. Namely, aflatoxin M1 has the ability to bind to casein, i.e. milk proteins. In yogurt and other fermented products, the amount of aflatoxin M1 is lower in the final product, due to the drop in pH value.

According to the Rulebook on Maximum Permitted Amounts for Certain Contaminants in Bosnia and Herzegovina, the maximum permitted amount of aflatoxin M1 in milk is 0.05 µg/kg. The European Union has prescribed the maximum allowed amount of aflatoxin M1 in milk and it amounts 0.05 µg/kg, and in milk for infants it amounts 0.025 µg/kg.

Through the chain of production, processing and distribution, aflatoxin M1 can reach consumers. In order to protect the health of consumers, it is necessary to perform a risk analysis of the presence of aflatoxin M1 in food.

Key words: *milk and milk products, aflatoxin M1, risk analysis*

IN VITRO INVESTIGATION OF WATER EMULSIONS AND MICROCAPSULES WITH ESSENTIAL OILS AGAINST AFLATOXIGENIC MOULD

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Abstract

The application of essential oils (EOs) in the form of emulsions and microcapsules, as a new way of applying these compounds in food, enables equal dispersion and distribution of the EOs in the matrix, reduces the decomposition of EOs by creating a physical barrier and enables a gradual and controlled release of the oil, which contributes to increased bioavailability and efficiency, that is, a longer-lasting effect. Therefore, the aim of this study was to determine the effect of water emulsions (EOs/W) and microcapsules with EOs of three medicinal plant from the Lamiaceae family: oregano (Origanum vulgare L.), winter savory (Satureja montana L.) and hyssop (Hyssopus officinalis L.), against toxigenic species Aspergillus flavus (isolated from corn flour), in vitro, including the determination of the antifungal activity of EOs individually and in a mixture (in a 1:1 ratio). EOs/W emulsions with the EOs concentation of 5% (w/w) stabilized by gum arabic were prepared by homogenisation as a first step, followed by ultrasonication to produce fine and stable emulsions. Microcapsules were prepared by spray-drying process. The core/wall material was 1:4 (w/w) in all formulations. Antifungal activity of EOs and EOs/W emulsion against A. flavus was tested by disk diffusion and microdilution method. Determination of the effect of microcapsules with EOs against A. flavus was performed in Sabouraud Maltose Broth (SMB). The results obtained by the disc-diffusion method indicate that the oregano EO and the EOs mixture of oregano and winter savory showed the largest zone of inhibition (90 mm). Oregano and winter savory EOs/W emulsions showed a zone of inhibition of 17 mm and 18 mm, respectively. Minimum inhibitory (MIC) and minimum fungicidal concentration (MFC) of EOs ranged from 0.11 µL/mL (oregano EO) to 454.54 µL/mL (hyssop EO). The EOs mixture of oregano and winter savory, as well as the EOs mixture of winter savory and hyssop showed a synergistic effect (FIC_{index}<1). MIC EOs/W emulsions ranged from 3.55 µL/mL (winter savory EO/W emulsion) to 227.27 µL/mL (hyssop EO/W emulsion), and MBC from 7.1 µL/mL (winter savory EO/W emulsion) to 454.54 µL/mL (hyssop EO/W emulsion). Microcapsules with oregano and winter savory EOs, as well as with a EOs mixture of oregano and winter savory, completely inhibited the growth of A. flavus in SMB, while microcapsules with hyssop EO reduced number of A. flavus by 0.5 log CFU/g. The obtained research indicates a significant antifungal potential of EOs/W emulsions and microcapsules with oregano and winter savory EOs, and represents a contribution to the development of a new concept of alternative methods in the food protection against mycological and mycotoxicological contamination.

***Key words**: Aspergillus flavus, essential oils, emulsion, microparticles, antimicrobial activity.*

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IN VITRO EVALUATION OF THE EFFICACY OF COLD PRESSED BLACKBERRY CAKE AS AN AFLATOXIN B1 ADSORBENT

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Abstract

In the recent times, sorption technology with agri-food wastes has proposed as an alternative over conventional binders with the benefits of low-cost, higher rentability, biosustainability and exceptional efficiencies. Nowadays, local and global trend of fruit growing intensification and fruit processing leads to the fact that the by-products represent large economic deficit and environmental problem. Disposal of by-products of the fruit processing industry is a growing problem because plant material is prone to microbiological spoilage and limits further exploitation, so the use of by-products has become one of the major challenges. The present work investigated the potential of the cold pressed blackberry cake (CPBC) as a novel aflatoxin B1 (AFB1) adsorbent from liquid mediums simulating physiological pH values (3 and 7). Scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), point of zero charge (pH_{pzc}) and Boehm titration analysis were used to characterize the adsorbent material. These analyses demonstrated the presence of several functional groups on CPBC surfaces, which may be involved in the binding mechanisms of AFB1. Main adsorption centers for the mycotoxins are assumed to be carboxyl and hydroxyl groups. Results obtained after the Boehm titration confirms more acidic groups (1.58 mmol/g) on the surface of the biosorbent than base groups (1.18 mmol/g). In biosorption study, an initial concentration of AFB1 for testing was 2 mg/ml, while the content of the solid phase of CPBC varied from 2-35 mg/ml. The samples were incubated at 37 °C for 120 min with agitation at 250 rpm. Concentrations of AFB1, in solution, before and after adsorption using CPBC, were determined by liquid chromatography (HPLC). It was observed that increasing the mass of CPBC up to 30 mg increased the adsorption efficiency. The maximum adsorption efficiency using the CPBC was 85.36% at pH 3 and 87.01% at pH 7. Hence, this study confirms that CPBC can be considered as a promising food by-product for AFB1 biosorption and can find technological applications as feed/food additives for mycotoxin detoxification.

Key words: *cold pressed blackberry cake, aflatoxin B1, biosorption, HPLC*

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TEXTURAL AND SURFACE CHARACTERIZATION OF SUGAR BEET PULP AS A BIOSORBENT FOR METAL IONS REMOVAL

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Abstract

Sugar beet pulp (SBP) as sugar-depleted by-product represents pectin-rich agroindustrial residue. From the prism of the sustainable development, reuse of the exhaused SBP contributed to closing material and energy flows. Finding a solution for the reuse of exhausted SBP transforms linear to circular bioeconomy on a micro level. Key role of the application of SBP as biosorbent for metal ions removal has surface of the biomaterial and their textural characteristics. Comprehensive analysis was conducted in this work regarding determining surface of the sugar beet pulp: Fourier transform infrared spectroscopy (FTIR), Scanning electron microscopy with energy dispersive X-ray spectrometry (SEM-EDX), thermogravimetric analysis (TGA), Boehm titrations, and detecting the point of zero charge (pH_{pzc}). The texture and surface of SBP were analyzed before and after the applied biosorption process of the removal of molassigenic metal ions (Na^+, K^+, Ca^{2+}) from the alkalized sugar juice. From the results obtained after the FTIR analysis could be concluded that main centers for the metal ions exchange are carboxyl, hydroxyl and phenyl functional groups. The graph obtained after thermogravimetric analysis confirms presence of the cellulose, hemicellulose and lignin in the structure of the sugar beet pulp which are mainly constructed of the carboxyl groups. Higher presence of the acidic groups on the surface of the sugar beet pulp (1.61mmol/g), than the base (0.25mmol/g), also confirms presence of the acid functional groups, possible proton donors for the exchange with molassigenic metal cations. Aditionally, acidic groups detected by the Boehm titration at the surface of sugar beet pulp after the applied biosorption process is smaller than before the process (1.10mmol/g). The pH working environment in which is conducted experiment (10.5) is convenient for the successful reduction of the present metal ions in alkalized juice, due to the negatively charged surface of the sugar beet pulp in the pH range higher than 10, whereas pH_{pzc} is 6.4. During this biosorption process morphological structure regarding the density of shrinks, cracks and surface smoothness is not changed at the significant level according to SEM micrographs. EDX used as detector, additionaly confirmed increase in the amount of Na^+, K^+, Ca^{2+} after the biosorption process at the surface of the sugar beet pulp. Therefore, SBP has appropriate surface structure suitable for the metal ions removal and at the same time process is not harmful to the environment and minimizes the depletion of this by-product from the sugar refinery.

Key words: *surface characterization, textural analysis, sugar beet pulp, metal ions removal*

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THE USE OF CHOLINE BUTYRATE FOR THE EXTRACTION OF 5-HYDROXHYMETHYLFURFURALE (HMF) FROM HONEY

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Abstract

Choline (2-hydroxyethyltrimethyl ammonium chloride) belongs to the class of quaternary ammonium salts and is always associated with an anion of the opposite charge (chloride, hydroxide, tartrate, butyrate). It is one of the most important biodegradable, inexpensive and water-soluble organic salt. Also, is a component present in the body and is considered a good biocompatible component of ionic liquids. Choline serves as a precursor molecule for the neurotransmitter acetylcholine, which plays a role in many functions, including memory and muscle control. It appears in the composition of the main groups of phosphatidylcholine and sphingomyelin, two classes of phospholipids that are present in cell membranes. Compared to ionic liquids containing imidazole or pyridine cations, ionic liquids with choline cations have lower toxicity and higher biodegradability. Choline-based ionic liquids are widely used today in the field of green, sustainable chemistry and in many chemical processes.

Honey is the only natural food product consumed in unprocessed form. Application of ionic liquids for the extraction and detection of some honey safety parameters (hydroxymethylfurfural and pesticides) can lead to greater efficiency of targeted analytes due to the possibility of designing the structure of ionic liquids. At the same time, applied systems do not affect the honey matrix. Also, designed systems can achieve greater selectivity of the extraction process, without the use of toxic solvents and with a reduction in the duration of the process.

The aim of this work was to develop and implement extraction procedures for isolating HMF from honey, in order to ensure its health safety and to enable the further application of isolated HMF in various branches of industry. Bio-ionic liquids are seen as an ideal extractant for both purposes, and additionally, they can be reused (recycled), which lowers the cost of the analysis/process, as well as environmental pollution. Using a two-phase system based on choline butyrate and potassium phosphate for the extraction of HMF from honey, maximum extraction efficiency was achieved (EE_{HMF} > 98%). Also, the mechanisms of HMF extraction using ionic liquids are explained based on the optimized structures of the ionic liquid system with HMF, together with the visualization of non-covalent interactions and on the basis of calculated binding energies ΔGbin, which can serve as a good predictor of the extraction potential of choline butyrate.

***Key words**: honey, HMF, ionic liquid*

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THERAPEUTIC PROPERTIES OF HONEY FROM THE WESTERN BALKANS

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Abstract

Honey is a natural sweetener produced not only for food, but also for therapeutic purposes. Carbohydrates (glucose and fructose (85–95%)) dominate in honey composition, but it contains about 200 substances present in small amounts (minerals, proteins, enzymes, amino acids, organic acids, vitamins, polyphenols and other phytochemicals).
The health benefits of honey, used for centuries for therapeutic purposes, derive from its antioxidant nature, antimicrobial and antiproliferative activity.
The antioxidant capacity of honey primarily depends on the phenolic profile of honey, which depends on its botanical and geographical variations. The antibacterial activity of honey results from the high osmolarity and acidity of honey, as well as the presence of hydrogen peroxide and phenolic compounds.
With the aim to assess the antioxidant capacity and antibacterial activity of different types of honey characteristic for the region, nineteen samples (acacia, linden, heather, sunflower, phacelia, basil, anise, sage, chestnut, hawthorn, buckwheat, lavender and meadow) were collected from different locations from the Wester Balkans region and examined. Honey samples were also tested for physicochemical parameters (moisture, pH value, electrical conductivity, free acidity and HMF) to ensure that they meet the requirements for honey quality.
Based on the physicochemical profile of honey samples, it was concluded that all of them were in accordance with the regulations of national and EU regulations.
The antioxidant potential of honey samples was assessed by determining the total phenol content (TPC) and evaluating the antiradical activity on diphenylpicrylhydrazyl radicals (DPPH·).
The highest phenol content was found in basil honey (101 ± 2.72 mg GAE/100 g), while the lowest was determined in rapeseed honey (11.5 ± 0.70 mg GAE /100 g). Heather, anise, phacelia, sage, chestnut and lavender honey samples were also abundant in phenolics (80–100 mg GAE/100 g). Scavenging activity on DPPH· was the highest in lavender honey (IC_{50} = 88.2 ± 2.11 mg/mL) and the lowest in rapeseed honey (IC_{50} = 646 ± 8.72 mg/mL).
Antibacterial activity was estimated in vitro using agar diffusion tests and measuring minimal inhibitory concentration (MIC). Among investigated bacterial strains following resistant potencies were determined: E. coli > E. coli ATCC 8739 > E. faecalis > Proteus mirabilis > S. aureus > S. epidermidis. The linden honey from Fruška Gora (MIC values of 3.12% and 6.25% against S. aureus and S. epidermidis, respectively) and phacelia honey (MIC values of 6.25% and 3.12% against S. aureus and S. epidermidis, respectively) showed the strongest antibacterial activity.

***Key words**: honey, antioxidant activity, antibacterial activity*

Note: This work was financially supported by the Ministry of Education, Science and Technological Development, Republic of Serbia (Contract No. 451-03-68/2022-14/200222).

STUDIES ON IMPROVING THE QUALITY OF APPLE JUICE

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Abstract

Natural apple juice is recommended in the diet due to its rich content of vitamins and antioxidants, it provides the human body with elements necessary for good functioning. The increase in the consumption of such juices has increased recently due to the beneficial health effects due to the low sodium content, the diuretic effect, the low cholesterol and fat content, the high concentration of vitamin C, polyphenols and antioxidants that have a significant role in the prevention of diseases. heart, cancer and diabetes. Antioxidant substances help reduce oxidative stress, neutralize free radicals and at the same time protect the body from their action. Fruit juice has a high caloric value due to its sugar content, but it is recommended in weight loss diets due to the feeling of satiety it provides after consumption. These sugars together with the organic acids give the juice its special taste, fresh, refreshing and inviting.
As a result of the research, I noticed various ways to improve the quality of natural apple juices. I will take into account both the apple varieties suitable for obtaining the juice and the care of the trees, the harvesting/storage conditions, the technological process used and the most suitable ways of packaging this juice to obtain a high quality juice. In order to produce high-quality juices, the degree of ripeness, texture, intensity and type of aroma, acidity, nutritional value, sugar content are important criteria in choosing the type of apple used to obtain the natural juice. Natural fresh apple juices obtained by pressing have a short shelf life, the need for immediate consumption resulted from microbiological and physico-chemical analyses. Refrigeration reduces the risk of contamination but does not significantly extend the juice's shelf life compared to pasteurization or freezing. The use of heat treatment is an effective method when we use high temperatures and short periods of time. Research is being pursued into the most effective method of extending the shelf life of natural apple juices. These researches in the specialty present various ways of packaging natural pasteurized apple juice. We will choose the most optimal method discovered that ensures obtaining and preserving the quality of this juice for a long period of time without requiring certain too expensive storage conditions.

***Key words**: apple juice, packaging, shelf life, antioxidants*

PROCESS PARAMETERS INFLUENCE ON BIODIESEL PRODUCTION FROM WTO

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Abstract

Biodiesel is diesel fuel made from vegetable oils, animal fats, or recycled restaurant greases. It's safe, biodegradable, and produces less air pollutants than petroleum-based diesel. Biodiesel is mainly produced by transesterification process using alcohol as a reactant. Under normal conditions, this reaction will proceed either very slowly or not at all, so heat, as well as catalysts (homogeneous or heterogeneous) are used to speed the reaction. In this paper biodiesel is produced from WTO (waste cooking oil) with methanol as a reactant and potassium hydroxide as catalyst. WTO is obtained from nearby restaurants in Zvornik area and consists of used vegetable sunflower oil and animal fats from cooking. Transesterification process was performed with different process parameters (time, concentration of catalyst and temperatures). Obtained products are compared to the biodiesel produced from the fresh sunflower oil. Using the data from the experiments it is possible to come to the conclusion what is the best conditions for biodiesel production from homogeneous base catalyst.

Key words: *biodiesel, homogeneous catalyst, methanol, transesterification, WTO*

OPTIMIZATION OF PLATE HEAT EXCHANGER OPERATION

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Abstract

Heat exchangers are process devices that carry out, as the word itself says, heat transfer and as such are an indispensable part of industrial and any other process. One of the most commonly used heat exchangers is the plate heat exchanger in both food and chemical technology. In this work, the influence of process conditions on the operation of a laboratory plate heat exchanger was studied. The effects of different hot and cold flows on heat transfer were examined, as well as the influence of the surface for heat exchange, i.e. the number of plates. The heat transfer coefficient was also determined for different conditions and temperatures of the hotter fluid. Heat losses for the mentioned changes in process parameters were also studied. Distilled water was used as the hot fluid, and running water from the city water supply was used as the cold fluid. Based on the obtained results, appropriate conclusions and observations were made that could be taken into consideration when designing plate heat exchangers of a larger scale in order to achieve savings and improve product quality.

Key words: *heat transfer, plate heat exchanger, optimization, fluid*

INFLUENCE OF PROCESS PARAMETERS ON MORPHOLOGICAL CHARACTERISTICS OF FINELY PRECIPITATED HYDRATE

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Abstract

In this paper, the influence of process parameters on the morphological characteristics of finely precipitated hydrate was examined. The research was conducted in order to synthesize finely precipitated aluminum hydroxide (FPH) from an aluminate solution obtained in Bayer's process. Finely precipitated hydrates obtained in this way are used mostly in the non-metallurgical industry. The finely precipitated hydrates thus obtained should be in accordance with certain qualities such as fineness, purity, specific surface, whiteness, etc. This paper presents the effects of a number of process parameters, such as precipitation temperature (t), amount and surface of additives, precipitation time, dilution, addition of aluminum sulfate (modifier) on particle size, their specific surface and morphology. At higher precipitation temperatures, the particle size increases, while at lower ones it decreases, and at lower temperatures of 40 °C, smaller hydrates are formed. It was found that the surface and amount of the additives have a significant effect on the particle size of the precipitated finely precipitated hydrate. Experimental data suggest that a larger specific area and amount of the additives favor the production of smaller particles with a larger specific surface area. By dilution of the starting aluminate at the same conditions, smaller hydrates were obtained, up to 30% lower medium diameter and 10-20% larger specific area. Also one of the important parameters that influenced the deposition process in relation to the particle size is the addition of modifiers, i.e. aluminum sulfate. The resulting SEM analysis of samples treated with aluminum sulfate confirmed a different structure of hydrates obtained by treatment with modifiers and the appearance of irregular shape of crystals and appearance formed from several layers. It has been observed that the formation of smaller particles is associated with the degree of nucleation rate, while the level of oversaturation controls the degree of nucleation rate.

Key words: *analysis, hydrate, process, particle, SEM*

DETERMINATION OF COPPER TRACES AROUND THE ENTRY BULLET HOLE

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Abstract

When solving crimes committed with the use of firearms, it is necessary, based on physical traces, to obtain a series of information for conducting the investigation. In addition to determining the type of weapon and ammunition used, the direction of the shot, the distance from which the shot was fired, etc., it is very important to determine whether certain mechanical damage originates from the projectile, and whether it is the entry bullet hole. Determining the entry bullet hole is usually done on the victim's clothing or other material through which the projectile first passed. The information about the entry bullet hole is very important both for the reconstruction of the shooting incident and the conducting an investigation, as well as for providing evidence for court proceedings. Determining the entry bullet hole is done by analyzing the presence of characteristic elements in the bullet wipe around the margin of the bullet hole, using chemical and physical-chemical methods and techniques. In addition to determining the presence of lead, antimony and barium, as characteristic elements that are found in the bullet wipe, the presence of copper can also be determined in cases of using ammunition with a copper-jacketed bullet. In this paper, the determination of copper in the bullet wipe at the edge of the entry bullet hole using dithiooxamide (DTO) and 2-nitroso-1-naphthol (2-NN) tests is presented. These are specific colorimetric reagents for the detection of copper that have been adapted to forensic needs. Dithiooxamide, also known as rubeanic acid, is very sensitive for copper, about 15 times more sensitive than the sodium rhodizonate test for lead. It is important to note that after applying the tests with the DTO or 2-NN reagents for copper, it is possible to apply a test for lead, which is present in almost all traces around the entry bullet holes. It is important to emphasize that, if both the copper and lead tests are to be carried out, tests for copper must be done first. Otherwise, the acidic solution used to transfer lead residues from the material will also transfer copper residues, and it will not remain for the subsequent testing. These relatively simple chemical methods are very practical because, in addition to the laboratory, they can also be used in the field during crime scene investigations.

Key words: *projectile, bullet hole, bullet wipe, dithiooxyamide, 2-nitroso-1-naphthol*

THE ROLE OF IRON ADDITION ON VIVIANITE FORMATION DURING ANAEROBIC SEWAGE SLUDGE DIGESTION

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Abstract

Phosphorus is an essential nutrient for all living organisms and is a key element for global food production as it is widely used as fertilizer. Since the start of the intensification of agriculture in the 1960s, the mineral fertilizer use increased by more than 700%, due to the global population growth as well as the changes in food consumption habits over the years. Phosphorus is recognized by the European Union as a critical raw material (CRM). So, it is of paramount importance to exploit secondary sources of phosphorus like sewage sludge. Phosphorus is present in wastewater mainly due to household cleaners and human excrements and is also identified as one of the main causes of eutrophication in water resources. While phosphorus removal technologies are well-established and widely applied, phosphorus recovery remains a challenge. Formation of Vivianite ($Fe^{2+}Fe^{2+}_2(PO_4)_2 \cdot 8H_2O$), a hydrated insoluble iron phosphate mineral, could increase the share of recoverable P in sludge. This way, the sustainable use of phosphorus, based on the circular economy principles, could be created.

The present study focuses on the role of different iron sources like Ferrous (Fe^{2+}), Ferric (Fe^{3+}), Metallic Iron (Fe^0) and recycled Ferric iron on vivianite formation and biomethane production during anaerobic sludge digestion. The main objectives of the current study are to identify the parameters that affect the production of biogas and vivianite and to recognise a possible symbiotic link between a WWTP and a water treatment plant, where the one will be the producer of mineral vivianite sustainably and the other will be the iron source provider (recycled ferric iron – spent coagulant), so that the whole process will be in line with the circular economy model and sustainable development.

This study shows that the use of extra iron during anaerobic sewage sludge digestion can facilitate vivianite formation and almost all phosphate can be bound in vivianite. On the other hand, iron addition can affect to some extent biomethane production i.e. 90-100 mlCH4/gVS are produced by samples with metallic iron source and control samples (without excess iron) while slighter quantities, 60-70 mlCH4/gVS, are produced when an excess of ferrous or ferric iron is used. XRD analysis proves the presence of vivianite and Optical Microscope analysis indicates its presence as free particles. This fact could potentially allow vivianite separation from the sludge and high phosphate recovery.

Key words: *vivianite, biomethane potential, sewage sludge, phosphorus recovery, circular economy*

INVESTIGATING THE POSSIBILITY OF USING SEWAGE SLUDGE ASH IN THE PRODUCTION OF COMPLEX MINERAL FERTILIZERS

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Abstract

The final by-product of municipal wastewater treatment is sewage sludge, which is classified as non-hazardous waste in European regulations. The commitment to a circular economy within the framework of the European Green Deal (The European Green Deal, COM/2019/640) has highlighted the fact that sludge should not be discarded as waste, but reused.
It is planned to build more than 300 plants for the treatment of waste municipal water in the Republic of Serbia by 2041, and therefore an increase in the amount of available municipal sludge is expected. As the company Elixir Group strives to do business according to the principles of the circular economy and as their focus of interest is environmental protection, it is planned to build a line at the Elixir Prahovo location by the end of 2025 that will deal exclusively with burning municipal sludge generated on the territory of the Republic Serbia. The world practice is that the largest amount of sewage sludge is burned, after which ashes are left, which are rich in phosphorus and can be used as fertilizer or as an addition to mineral fertilizers. The content of phosphorus in ash from the burning of sewage sludge can reach up to 15%, and ash with an average amount of phosphorus of about 8% corresponds in content to the amount found in medium-rich phosphate mineral deposits. In accordance with that, this paper examines the possibility of using ash produced after the thermal treatment of sewage sludge as a potential raw material in the production of mineral phosphate fertilizers. For this purpose, the laboratory production of complex fertilizers was carried out, in which part of the raw phosphate was replaced by ash from sewage sludge. The results of the research showed that from the economic, but also the ecological side, the use of ash is very suitable, and apart from the fact that it may have a slight effect on the reduction of water-soluble P2O5 and on the change in the color of the final product, there are no significant negative consequences. The ash used showed a positive effect on the shape of the granules and reduced caking. Physico-chemical analyzes showed that the used ash has a very low content of moisture, organic matter, heavy metals, chlorides and fluorides, which is very suitable when choosing a new raw material in the production of mineral fertilizers.
The use of alternative raw materials, such as ash, in the production of fertilizers is allowed and recommended by the regulation of the European Parliament and the Council (EC 2019/1009) which applies from July 2022.

Key words: *phosphate crisis, sewage sludge ash, chemical composition, complex mineral fertilizers, granulation*

DETERMINATION OF THE QUALITY PARAMETERS OF COMPOTE OBTAINED FROM DONE FRUITS

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Abstract

The paper describes the production of composes of stone fruit, the action methods, followed by a quality parameters, determining the dry matter index, the method of refractometry, determining the contents of volatile acids in products of Fruits and vegetables, pH determination, determination of total acidity, color determination and sensory assessment. The most important characteristics that were examined in this work on different types of composes, and in order to obtain the quality of composes are sensory analysis. Sensory analyzes There was a conclusion that the color, taste, taste and smell of composes of cherry, plum, cherries, peaches and apricots at a very satisfactory level, confirm and evaluations obtained by three evaluators. In order to preserve and maintain the characteristics of the quality of composes, it should take into account stored space, temperature and relative humidity, where compote is saved. Only thus quality parameters can be preserved, there will be no corruption until it will come. Sugar stability in the raw materials themselves is of great importance later for the finished product, because sugars are partly responsible for the quality and admissibility of the fruit after can. Sugars participate in the formation of taste, sweetness and total sensory quality of fruits. Analysis of pH values in different types of composes, it turned out that the cherry compote also has the highest source, 8.57, which is also expected, because the cherry itself contains a large amount of acidic. The Ad Index is the largest in the apricot compote is 6.82. To assess organoleptic characteristics, colors, taste and smell, evaluators gave approximately the same ratings.

Key words: *Stone fruit, technological process, canning methods, quality parameters*

FTIR ANALYSIS IN ASSESSMENT OF COMPLEX COACERVATION OF PUMPKIN LEAF PROTEINS AND NATURAL POLYSACCHARIDES

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Abstract

Complex coacervation using plant proteins and polysaccharides is atractive field of science nowadays. The application of plant proteins instead of animal proteins in complex coacervation enabled overcoming of some drawbacks linked with the production of animal proteins and its environmental impact, the spread of diseases, pathogens etc. The sustainable research based on extraction of waste leaf biomass as a rich source of plant proteins can contribute to wider usage of plant proteins in coacervation.

The aim of this work protein extraction from pumpkin leaves, using different procedures: thermal-acidic (TA), alkaline-acidic (AA) and ammonium-sulfate (AS) precipitation. "Green fraction" was precipitated by heating pumpkin leaf juice to 50^{o}C for 30 min (TA and AS), or by adjusting pH to 10 (AA). "White protein fraction" was then precipitated from the supernatant by adjusting pH to 4 (TA and AA) or by addition of ammonium-sulfate (50% w/v)(AS) and freeze-dried. The samples were subjected to electrophoresis to determine the presence of RuBisCO. Further, the isolates were used for preparation of complex coacervates in interaction with alginate. The formation of complex coacetvates (TA-A, AA-A and AS-A) in colloid solution was detected by changes in optical density in the pH range 7.00-1.50, at 600 nm. Prepared samples were then freeze-dried and examined using FTIR.

Electrophoresis confirmed the presence of RuBisCO in TA and AS, but all three protein-enriched fractions had very similar FTIR spectra with most dominant bands found in the peptide carbonyl region (1635 and 1515 cm^{-1}); these bands were of the highest relative intensity in AS, indicating the highest protein content. FTIR spectrum of the alginate exhibited characteristic bands at 1725 and 1601 cm^{-1}, corresponding to carboxylic acid/carboxylate groups, respectively. Bands associated with sugar structures (C-O bonds), in the range between 1200 and 800 cm^{-1} were well developed, with a band peaking at 1030 cm^{-1} being the most dominant. The spectra of the coacervates resembled mostly those of the protein samples. The presence of alginate was confirmed in AA-A and AS-A, as in the FTIR spectra of these samples the band at 1030 cm^{-1} was more pronounced (higher intensity in AS-A). The results showed that, while all samples exhibited precipitation at pH4, complexion with alginate was observed only in AA and AS, and that AS was capable of binding greater amount of alginate. Therefore, the method of protein isolation is of great importance for its ability to form coacervates.

Key words: *FTIR, Coacervation, Pumpkin leaf, Proteins, Extraction*

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MACERATION AND HEAT-ASSISTED EXTRACTION OF POLYPHENOLS FROM *ALOE VERA*

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Abstract

Aloe vera (L.) Burm. f. (Asphodelaceae) contains anthraquinones, their glycosides, flavonoids, tannins, terpenoids, saponins, resins, mono- and polysaccharides, polypeptides, lectins, enzymes, vitamins, and minerals. The plant is used in traditional medicine due to its antitumor, antioxidant, anti-inflammatory, antiulcerogenic, immunomodulatory, analgesic, and dermal protection properties. Maceration and heat-assisted extraction (HAE) are frequently used extraction procedures because of their simple operation and low costs. In the present study, A. vera dried leaves were extracted using ethanol (50%, V/V; drug solvent ratio 1:30, w/V). The influence of different extraction times (30-120 min for maceration and 15-60 min for HAE), and various extraction temperatures (40, 60, and 80ºC) in HAE on the total polyphenol content (TPC) and radical scavenging potential (ABTS and DPPH methods) was evaluated, while for the most prominent extracts (with the highest TPC) zeta potential and conductivity were additionally analyzed. Regarding maceration, the TPC was correlated with the rise in extraction time up to 45 min (from 7.8±0.72 to 9.66±0.51 mg gallic acid equivalents (GAE)/g of plant material) and after that reached the steady state (~9.1 mg GAE/g). In HAE, no statistically significant differences between the TPC of the extracts obtained after 15, 30, and 45 min (9.77±0.32, 9.76±0.18, and 9.95±0.50 mg GAE/g) were not observed, while the extract prepared after 60 min showed significantly lower TPC (8.14±0.08 mg GAE/g). The TPC was in correlation with the increase of extraction temperatures (9.08±0.21 at 40ºC, 9.38±0.10 at 60ºC, and 9.86±0.24 mg GAE/g at 80ºC). As in the case of TPC results, anti-ABTS activity was significantly different between 30 and 45 min of maceration and reached the steady state after 45 min (~2.01 mmol Trolox/g of plant material). In HAE, the anti-ABTS potential of the extracts obtained at different extraction times was comparable (1.44-1.64 mmol Trolox/g), whereas the activity of the extract obtained at 40ºC was lower. DPPH radical scavenging activity rose after 45 min of maceration when also reached the steady state (~40.4 mg/mL), but there were no significant differences between the extracts prepared at different extraction times in HAE, and IC_{50} was lower for the extract obtained at 80ºC. Hence, the macerate prepared after 45 min and HAE extract obtained after 15 min at 80ºC exhibited very low zeta potential (0.14±0.06 and 0.50±0.01 mV), and conductivity (1.05±0.07 and 0.98±0.01 mS/cm). This study was an initial step in the production of A. vera polyphenol extracts aimed to be used for the formulation of foodstuffs, medicines, and cosmetics.

Key words: *Aloe vera, antiradical activity, conductivity, polyphenols, zeta potential.*

THE INFLUENCE OF ULTRASOUND EXPOSURE TIME ON POLYPHENOL AND FLAVONOID YIELD AND ANTIOXIDANT POTENTIAL OF *SATUREJA MONTANA* L. EXTRACTS

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Abstract

Satureja montana L. (winter savory, Lamiaceae), as an evergreen perennial aromatic plant, contains essential oil, phenolic acids, flavonoids, labiatic acid, proteins, vitamins, and minerals. S. montana extracts have shown various pharmacological properties, such as antioxidant, antibacterial, antiviral, antitumor, anticatarrhal, and stimulant activities. Ultrasound-assisted extraction represents a modern extraction procedure that provides a higher extraction yield, fast kinetics, the use of a wide range of extraction solvents, a simple operation, and low costs in comparison to other novel techniques. In the present study, S. montana extracts were prepared using dried plant material (0.5 g), 50% ethanol as an extraction solvent (10 mL), and different extraction times (5, 15, 30, and 60 min) in an ultrasound bath. The extracts were analyzed via polyphenol and flavonoid yields, as well as DPPH radical scavenging activity. The total polyphenol content of the extracts rose up to the 15th min (from 12.7±0.7 to 20.6±0.4 mg gallic acid equivalents (GAE)/g of plant material) and after that reached the steady state (~21 mg GAE/g). The total flavonoid content was also rising with the increase in extraction time, from 4.34±0.28 mg catechin equivalents (CE)/g of plant material after 5 min to 8.19±0.36 and 8.42±0.30 mg CE/g after 15 and 30 min, respectively. However, the flavonoid concentration significantly decreased after 60 min of ultrasound-assisted extraction (7.38±0.32 mg CE/g). The extraction time significantly affected the DPPH radical scavenging capacity of the extracts: 65.4% after 5 min, 94.5±1.3% after 15 min, 87.0% after 30 min, and 91.6±1.3% after 60 min. According to the presented results, it can be concluded that 15 min represents the optimal ultrasound exposure time to obtain the extracts with the highest polyphenol and flavonoid yields, as well as DPPH antioxidant activity. The presented study shows the possibilities for the production of S. montana extracts with antioxidant compounds that can be potentially implemented in food, functional food, dietary supplements, pharmaceuticals, and cosmetics.

Key words: *Antioxidant activity, flavonoids, polyphenols, Satureja montana, ultrasound-assisted extraction*

CHEMICAL COMPOSITION AND ANTIOXIDANT CAPACITY OF THE ESSENTIAL OILS FROM TWO CHEMOTYPES OF *SATUREJA MONTANA* L.

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Abstract

Medicinal and aromatic plants have been traditionally used as an important source of therapeutic constituents. The genus Satureja contains about 200 aromatic and medicinal plant species, which grow in the Middle East and Mediterranean European regions, West Asia, North Africa, and South America. Satureja montana L. commonly contains around 5% of the essential oil that shows antioxidant, antimicrobial, diuretic, antidiarrheal, anticholinesterase, carminative, digestive, and cytotoxic activities. The essential oil provides the basis for a wide range of biological and industrial applications due to a high content of biologically active constituents. In the present study, the essential oils from two chemotypes of S. montana, ct. carvacrol (SM_c), and ct. thymol (SM_t) were isolated using a conventional hydro-distillation method (100 g of plant/1500 mL of dH_2O, 3 h). The areal parts of S. montana flowering plants were harvested from the experimental field of the Institute for Medicinal Plants Research "Dr Josif Pančić" in Pančevo, South Banat, Serbia. The chemical composition of the obtained essential oils was determined using GC-MS analysis, while antioxidant capacity was examined using two antioxidant assays (ABTS and DPPH methods). The GC-MS analysis showed that in the SM_c essential oil 43 compounds were identified and quantified, while in the SM_t essential oil there were 45 compounds. The most dominant compound in SM_c essential oil was carvacrol (39.49%), followed by thymol (30.43%), γ-terpinene (9.68%), p-cimene (5.71%), trans-caryophyllene (2.42%), β-bisabolene (1.96%), α-terpinene (1.41%) borneol (1.35%), myrcene (1.08%), and 1-octen-3-ol (1.04%), while the remaining constituents were presented in the amounts below 1% of the total content. The most abundant component in SM_t essential oil was thymol (70.69%), followed by carvacrol (7.06%), p-cimene (5.71%), γ-terpinene (3.85%), β-bisabolene (2.44%), and borneol (1.10%), whereas other oil constituents ranged from 0.03 to 0.89%. For SM_c and SM_t essential oils, the total content of monoterpene hydrocarbons was 19.61 and 12.99%, of oxygenated monoterpenes, 74.83 and 82.13%, of sesquiterpene hydrocarbons, 4.91 and 3.95%, and of oxygenated sesquiterpenes, 0.36 and 0.51%, respectively. According to the ABTS experiment, SM_c and SM_t had antioxidant capacities of 96.5 and 98.2%, respectively, whereas their respective capacities to neutralize DPPH radicals were 92.0 and 89.8%. The research presented here provides evidence on the chemical composition as well as the ABTS and DPPH radical scavenging potential of two different chemotypes of S. montana essential oils, as well as a foundation for their potential encapsulation and further application.

Key words: *Winter savory, carvacrol, thymol, essential oil properties*

COMPARISON OF MACERATION AND ULTRASOUND-ASSISTED EXTRACTION OF ANTIOXIDANT COMPOUNDS FROM *VACCINIUM MYRTILLUS* L.

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Abstract

Vaccinium myrtillus L. (Ericaceae), a perennial, wild, and small deciduous shrub that grows in the mountains and forests of Europe, contains anthocyanins, phenolic acids, flavonoids, fatty acids, stilbenes, iridoid glycosides, dietary fibers, vitamins, and minerals. The leaves' extracts are widely used in traditional medicine due to their astringent, antiseptic, antioxidant, anti-inflammatory, skin-rejuvenating, lipid-lowering, hypolipidemic, and hypoglycemic activities. The novel extraction techniques, including microwave-assisted extraction, provide various benefits, such as reducing solvent consumption and extraction time and increasing extraction yield, and quality. Hence, in the present study, V. myrtillus extracts were prepared using dried leaves (0.66 g), 50% ethanol as the extraction solvents (20 mL), and maceration (60 min) or ultrasound-assisted extraction (ultrasound probe, amplitude of 60% for 5 min). The obtained extracts were examined in terms of total polyphenol content (TPC) and antioxidant activity (ABTS, DPPH, FRAP, and CUPRAC assays). The TPC of the extract prepared using maceration was 55.2±0.7 mg gallic acid equivalents (GAE)/g of plant material, while the TPC of the extract prepared using an ultrasound probe was 55.6±1.0 mg GAE/g. The DPPH radical scavenging activities of the extracts correlated with the TPC and amounted to 1.81±0.05 mg/mL for macerate and 1.79±0.02 mg/mL for the extract obtained using an ultrasound probe, whereas ABTS antioxidant capacity did not correlate with the polyphenol concentration, 31.4±0.9 µmol Trolox equivalents (TE)/g for the macerate and 43.4±1.1 µmol TE/g for the extract from the ultrasound-assisted extraction. According to the results of FRAP and CUPRAC assays, the antioxidant potential was similar for both extracts (15.3±0.2 and 15.5±0.2 µmol Fe^{2+}/g and 45.7±0.5 and 46.0±0.7 µmol TE/g, respectively). Due to higher ABTS radical scavenging potential and significantly shorter extraction time, V. myrtillus extract prepared using an ultrasound probe was favored. The present research was an initial step in the preparation of V. myrtillus extracts which can be potentially implemented in food, pharmaceutical, and cosmetic formulations.

Key words: *Antioxidant activity, maceration, ultrasound-assisted extraction, polyphenols, Vaccinium myrtillus*

OPTIMIZATION OF LINDANE SORPTION FROM AQUEOUS SOLUTION BY MACROPOROUS COPOLYMER USING EXPERIMENTAL DESIGN

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Abstract

In the present study, synthesized macroporous copolymer was used for the sorption of lindane from an aqueous solution. This organochlorine pesticide is classified, according to US EPA, as mutagenic and teratogenic. Residues of lindane can persist in the environment, migrate long distances, and cause widespread contamination. In this way, lindane residues can reach the human body through the food chain. The usage of this pesticide is banned in most countries. However, lindane remains a serious toxicological problem at industrial sites where lindane was used coupled with improper wastewater disposal and has led to serious contamination. In addition, some countries still allow the production and use of lindane, and despite localized restrictions, lindane contamination remains a global problem. Taking into account these reasons, its removal from the environment is of a great significance. The obtained macroporous copolymer was syntesized via suspension copolymerization and was characterized by Fourier transform infrared spectroscopy (FT-IR), and scanning electron microscopy (SEM). The parameters which affect sorption efficiency of the lindane were: pH, sorption time (t_{sor}), ion strength (ion), rpm, and dose of sorbent. These variables were optimized by the experimental design which include Plackett-Burman Design (PBD) and Central Composite Design (CCD). After screening step by the PBD, the optimum conditions were obtained by the CCD where the values were investigated in two levels. The design of experiment showed that the ion strength and dose of sorbent were the most significant parameters, while the other variables do not have such an effect on sorption efficiency. Accordingly, the optimum conditions to reach the maximum recovery were: pH 8, 180 min sorption time, 300 rpm, 2 w/v % ion strength and 8 g/l dose of sorbent. The results showed that the studied copolymer could be an efficient sorbent for trace lindane in water with recoveries above 80 %.

Key words: *organochlorine pesticide, design of experiment, DoE, macroporous copolymer, optimization*

KINETICS AND ISOTHERMS MODELING OF SILVER REMOVAL ONTO MACROPOROUS AMINO SORBENT

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Abstract

Silver as one of the most known precious metal is used on a large scale in various industrial branches and the release of silver ions from such industrial activities potentially can cause serious environmental problems. Therefore, the removal of this metal from wastewater is a great challenge, and it is crucial for the quality improvement of the environment. Porous polymer materials with high specific surface areas and other specific physical and chemical characteristics have gained much attention as sorbents in the field of environmental protection. In this paper, macroporous poly(glycidyl methacrylate-co-ethylene glycol dimethacrylate) copolymer synthesized by suspension copolymerization and functionalized with diethylenetriamine was employed for silver ions sorption from aqueous solution at unadjucted pH and room temperature. The sorption kinetics and isotherms were studied to establish the mechanisms of sorption process. The kinetic data were modeled with pseudo-first-order (PFO), pseudo-second-order (PSO), Elovich and fractional power (FP) models as well as intraparticle diffusion (IPD) and liquid diffusion model (LFD), while the equilibrium data were analized using Langmuir, Freundlich, Sips and Redlich-Peterson isotherm models. Eight error functions such as coefficient of determination (R^2), Marquardt's percent standard deviation (MPSD), Chi-square statistic test (χ^2), hybrid fractional error function (HYBRID), the root mean square error (RMSE), the sum of the errors squared (SSE), sum of the absolute errors (SAE), and average relative error (ARE) were used to estimate the error deviations between theoretically predicted and experimental values of sorption capacities. The best kinetic and isotherm models were determined by normalizing eight error functions and finding the sum of normalized error value (SNE). The sorption kinetic studies revealed that the sorption of silver by macroporous amino-functionalized sorbent obeys the PSO kinetic model. In addition, the results indicate that sorption was governed by intraparticle diffusion with the evident influence of liquid film diffusion. The obtained results showed that the sorption isotherm data were satisfactorily fitted to the Redlich-Peterson isotherm model.

Key words: *silver, macroporous sorbent, error functions, glycidyl methacrylate, sorption*

WHEAT STARCH WET-MILLING PRODUCTS AS POTENTIAL RAW MATERIAL FOR BIOETHANOL PRODUCTION

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Abstract

Intensive use and constant necessity for continuous energy supplies has emerged as modern world issue. Nowadays fossil fuels represent the primary energy source used worldwide. In recent decades bioethanol was promoted as one of the most perspective renewable sources of energy and an environmentally friendly alternative to fossil fuels. Currently, several substrates are used as raw materials for successful bioethanol production, such as edible crops, agricultural waste, algal biomass. Raw materials containing starch are commonly used for the production of ethanol by alcoholic fermentation worldwide. Starch is mainly present in different types of cereals, tubers, roots and legumes which are characterized by a significant presence of carbohydrates and proteins. Wheat, corn, rice, potato and cassava represent the usual starch-containing raw materials used for bioethanol production. In addition to the mentioned substrates, some intermediate and by-products formed during the industrial production of wheat-based starch appeared as highly potential sources of starch for bioethanol production. Wet-milling of wheat flour is currently used for food-grade starch production and gluten. Wheat gluten applications are predominant in baked goods and processed meat products, while remaining starch suspension is sieved to remove residual non-starch components and dried to a moisture content of 14-15% to satisfy quality criteria for wide range of applications in food, feed, pharmaceutical and chemical industry. In order to meet market requirements, the possibility of applying intermediate and by-products of industrial wheat processing for bioethanol production was considered in this work. Ethanol yield and industrial productivity are highly dependent on the efficiency of starch hydrolysis and alcoholic fermentation by yeast, usually Saccharomyces cerevisiae. Therefore, different technological process concepts for bioethanol production are proposed and ethanol yield was predicted on the basis of substrate composition. In general, overall synthesis of ethanol in industrial processing is usually limited to 95% conversion of starch to ethanol. For these conditions it may be predicted that 0,112 l of pure alcohol may be produced from starch suspension containing 25% (w/w) of starch. Intermediate and by-products of wheat starch production were found to be excellent raw materials for bioethanol production due to the mild hydrolysis conditions, small amounts of residual proteins, pentoses, fiber, and fats.

Key words: *bioethanol, biofuel, starch suspension, raw material, wheat*

PRELIMINARY CHEMICAL ANALYSIS OF WILLOW LEAF EXTRACTS OBTAINED BY ULTRASOUND-ASSISTED EXTRACTION

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Abstract

In contrast to the well-documented medicinal use of willow bark (Salix spp., Salicaceae) as analgesic, antipyretic and anti-inflammatory agent, leaves of willow species were mainly discarded as waste after bark collection and not studied until recently. There has been a global trend towards the use of waste products from medicinal plants as valuable sources of bioactive compounds. Also, interest in application of environmentally friendly extraction techniques and solvents is growing. Ultrasound-assisted extraction (UAE) is a simple, inexpensive, 'green' extraction technique which could be used effectively for isolation of bioactive compounds from plant material. Therefore, the aim of this study was to analyze and compare the total phenolic and flavonoid content, as well as antioxidant profile of leaf extracts of five different willow species (S. alba, S. amplexicaulis, S. babylonica, S. fragilis, S. triandra) obtained by ultrasound-assisted extraction (UAE).

UAE was carried out in ultrasonic bath at 25°C for 30 min, using water as solvent. Total phenolic and flavonoid contents were determined by spectrophotometric methods.

Antioxidant activity of extracts was evaluated by 2,2-diphenyl-1-picrylhydrazyl (DPPH) and hydroxyl (OH) radical scavenging assays.

Total phenolic and flavonoid contents were in range from 1.98-17.07 mg GAE/g d.w. and 1.45-29.26 mg QE/g d.w., respectively. The highest amount of total phenolics and flavonoids was found in leaf extract of S. amplexicaulis, while the lowest in S. babylonica. DPPH radical scavenging capacities (IC_{50}) ranged from 4.35 to 44.29 µg/mL, while those of OH radical from 15.34 to 32.61 µg/mL. Extract of S. triandra exhibited the strongest DPPH scavenging activity, while S. alba inhibited OH radical the most.

The obtained results indicate that certain willow leaf extracts exert strong antioxidant activity and contain significant amounts of bioactive compounds, suggesting they could be further explored for pharmaceutical purposes.

Key words: *Salix, leaf, ultrasound-assisted extraction, antioxidant*

GREEN EXTRACTION OF BIOACTIVE COMPOUNDS FROM LAMIACEAE PLANTS

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Abstract

In recent years, increasing attention has been directed towards the development of green solvents in the field of extraction. Deep eutectic solvents (DES) are considered excellent alternatives for traditional organic solvents, which can be applied for the extraction of phytochemicals from various materials.
The objective of the work was to examine the effectiveness of DES as extragens of phenolic compounds from herbal drugs. In this experiment single-component teas of the Lamiaceae family, produced at the Institute for the Study of Medicinal Plants, "Dr. Josif Pančić", were used. 10 samples of herbal drugs were examined (oregano, lavender, basil, winter savory, garden thyme, wild thyme, sage, rosemary, lemon balm and mint). Extraction was performed with DES (a mixture of menthol and dodecanoic acid). The content of phenolic acids and flavonoids in the tested preparations was determined using high performance liquid chromatography (HPLC). Deep eutectic solvent, consists of menthol and dodecanoic acid (2:1), was made by weight appropriate amounts of each component.
Extraction with a mixture of menthol and dodecanoic acid (2:1) proved effective in isolating coumarin acid (0.02-0.03 mg/g of drug), quercetin (0.11-0.20 mg/g of drug) and naringenin (0.29-0.34 mg/g of drug). Cinnamic acid was extracted from lavender. DES, menthol:dodecanoic acid, has better affinity to less polar substances with aromatic compounds and doble bonds.
In this study an environmentally friendly, economic and efficient approach based on menthol and dodecanoic acid was applied for the extraction of phenolic compounds from Lamiaceae plants. Based on the presented results, DES can be useful in the isolation of some targeted compounds from plants. This solvent could be applied, as effective green solvent, in the human health promoting areas as ready-to-use products, like the food and pharmaceutical industries.

Key words: *green solvents, DES, extraction, Lamiaceae*

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THE INFLUENCE OF SYNTHESIS METHODS ON PHOTODEGRADATION EFFICIENCY OF ZnFe BASED PHOTOCATALYSTS

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Abstract

Organic dye pollutants that are progressively used in modern chemical industries, have recently emerged as a major source of water contamination. Considering the hazardous and carcinogenic properties of dyes, their removal from water eco-systems is challenging and has been upgraded to a matter of highest importance. A promising environmentally friendly and cost-effective approach to water purification is the heterogeneous photocatalytic process that utilizes various metal oxide semiconductors in the presence of light initiated oxidation-reduction reactions resulting in dye degradation. The aim of this study was to investigate the influence of synthesis method on photodegradation efficiency of ZnFe based photocatalysts. The photocatalysts were synthesized using two different coprecipitation methods: low(LS) and high (HS) supersaturation The precipitates were thermally treated/activated at 100, 300, 500 and 700°C. Structural and textural characterization was carried out for all prepared samples and their efficiency in photodegradation of methylene blue (MB) was monitored. Photodegradation experiments were conducted in an open cylindrical Pyrex reaction vessel containing 100 ml of test solution (C(MB)=10 mg/l) and 50 mg of powdered photocatalyst. At defined time intervals aliquots were centrifuged and MB concentrations were determined using UV-VIS spectrophotometer at 664 nm. Significant difference in photodegradation efficiency among photocatalysts synthesized by different methods was observed. The study revealed that LS samples thermally treated at 100°C and 300°C had low photodegradation efficiency, whereas HS samples thermally treated at same temperatures showed high MB photodegradation efficiency (65% and 85% after 180 min of UV irradiation). Furthermore, both LS and HS samples thermally treated at 500°C and 700°C exhibited high photodegradation efficiency, but the duration of the photodegradation was longer when applying LS samples. The performance difference in the photodegradation efficiency of LS and HS samples could be explained with different structural and textural properties triggered by different synthesis methods. ZnFe based photocatalysts synthesized by both LS and HS methods demonstrated promising photocatalytic performance indicating their great potential for the application in photocatalytic wastewater treatment. Nevertheless, HS samples exhibited excellent photodegradation efficiency most probably due to the optimal properties obtained by the HS synthesis method that played a major role in tailoring functional properties of ZnFe photocatalysts necessary for the successful MB photodegradation process.

Key words: *mixed metal oxides, photocatalysis, methylene blue*

Acknowledgements: This work was supported by the Science Fund of the Republic of Serbia, project no. 7737365, ZERO-WASTE CONCEPT FOR FLOOD RESILIENT CITIES – Ø-Waste-Water.

REVIEW OF MICROBIOLOGICAL PURITY IN THE FOOD CHAIN

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Abstract

A very important link in the microbiology of the food chain, in addition to the microbiological criteria for food (food safety criteria and hygiene criteria in the production process), are the criteria of microbiological purity. The aim of the research is to assess the state of microbiological purity in the food chain. Samples of swabs of equipment, devices, utensils, work surfaces, work clothes and hands of workers in production, processing and traffic in facilities and means of transport that come into contact with food, where there is a risk of the appearance and spread of an infectious disease, were used as test material. The samples come from facilities for the production, processing and distribution of food, restaurants and other catering establishments where food is served, facilities in the field of upbringing, education and social protection (facilities for housing people) and means of transport that come into contact with food. The examination was carried out during 2018 (4564 samples) and 2019 (5019 samples). The samples were tested for colony count, Enterobacteriaceae, Salmonella and Listeria monocytogenes, using the methods BAS EN ISO 4833-1, BAS EN ISO 21528-2, BAS EN ISO 6579-1 and BAS EN ISO 11290-1. The greatest risk of unacceptable microbiological purity in the food chain comes from the categories "Plates, bowls, cutlery and small dishes; dishes and utensils that come in contact with food" and "Hands of food handlers".

Key words: *microbiological purity, food chain, colony count, Enterobacteriaceae, Salmonella, Listeria monocytogenes*

MICROBIOLOGICAL STATUS OF WATER IN THE FOOD INDUSTRY

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Abstract

The microbiological quality of water is commonly defined as a maximum acceptable number or concentration of bacteria that do not constitute a health hazard. Zero-probability level of microbiological contamination of drinking water does not exist. Indicator organisms are used to assess the microbiological quality of water. The aim of the research is to determine the microbiological status of water in the food industry. Whilst the presence of coliform bacteria does not always indicate a public health threat, their detection is a useful indication that treatment operations should be investigated. The use of indicator bacteria, in particular E. coli and the coliform bacteria, as a means of assessing the potential presence of water-borne pathogens has been paramount to protecting public health. The research included samples of water used in the food industry. The samples come from the meat, milk and fish industry and catering facilities (ready to eat food). The examination was carried out during 2021 and included 194 samples, of which 73.20% originated from the water supply system, and 26.80% from wells. The samples were tested using the methods BAS EN ISO 6222, BAS EN ISO 7899-2 and BAS EN ISO 9308-1/A1. Of the total number of tested samples, 82.99% were satisfactory, and 17.01% were unsatisfactory. Intestinal enterococci were detected in 1.55% of samples, Escherichia coli in 5.15%, and coliform bacteria in 5.67% of samples. Water used in the food industry carries with it a constant microbiological risk of food contamination, given the presence of coliform bacteria, Escherichia coli and intestinal enterococci, both in water supply system and well supply system.

Key words: *microbiology, water, food industry, intestinal enterococci, Escherichia coli, coliforms*

QUALITY OF HONEY AND SUSPICION OF HONEY ADULTERATION

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Abstract

In addition to being used as food, honey has been used as an alternative medicine for thousands of years. It is a characteristically sweet food because sugars are the main ingredients of honey, comprising approximately 95% of the dry weight, and the most dominant are fructose, glucose, and sucrose. According to current standards, it is not allowed to add any other ingredients or additives to honey. Unfortunately, honey-like products are being marketed but do not have the nutritional value that consumers expect from honey. Such products can endanger people's health. The aim of this paper is to evaluate the quality of honey submitted for testing within the framework of official control on the market of Republic of Srpska and to provide results of parameters that are not in accordance with the valid regulations for honey in connection with possible honey adulteration. 217 samples of honey were tested for quality according to user specifications for one quality criterion or all physico-chemical parameters in accordance with legal regulations. Determination of all quality parameters except diastase was carried out according to the Rulebook on methods of control of honey and other bee products, and diastase activity (Schade unit) according to the International Honey Commission. Since HMF and diastase show the highest percentages of non-compliance with regulatory standards, laboratory testing determined that quality control of honey is necessary, especially considering the quantities present. It can be suspected that the honey is adulterated, but due to the limited capabilities of the laboratory, this cannot be verified. Additional tests are needed to prove the authenticity of the honey.

Key words: *quality of honey, HMF, diastase, honey adulteration, authenticity of the honey*

MICROBIOLOGICAL STATUS OF MINCED MEAT, MECHANICALLY SEPARATED MEAT AND SHAPED MINCED MEAT ACCORDING TO PROCESS HYGIENE CRITERIA

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Abstract

Meat is a highly nutritious food, but it is also suitable for the reproduction of microorganisms and thus the spoilage of meat, especially since minced meat requires a greater number of manipulations or processing procedures in its processing. Microbiological criteria are intended to give a certain degree of guarantee that food is safe, correct and of appropriate quality within the period of use, if it is handled in the prescribed manner. Microbiological criteria can be applied at different points in the food chain, during food production and/or evaluation of the finished product. The aim of the research is to determine the microbiological status of minced meat, mechanically separated meat and shaped minced meat in relation to process hygiene criteria. In the period 2021-2022, a total of 1,749 samples were tested, of which 802 samples were minced meat, 28 mechanically separated meat and 919 shaped minced meat. In relation to the tested parameter, 696 samples were tested for total count at 30°C and 1,053 samples for Escherichia coli. The samples were taken from the production phase. The methods BAS EN ISO 4833-1 and BAS EN ISO 16649-2 were used in the research. In the production process, an increase in the number of manipulative procedures leads to an increase in the total count at 30°C in meat and meat products. Due to the specifics of the production process, mechanically separated meat contains a higher number of Escherichia coli compared to minced meat and shaped minced meat. Hygiene in the production process leads to a reduced risk of total count at 30°C and Escherichia coli in minced meat, mechanically separated meat and shaped minced meat.

Key words: *microbiology, minced meat, mechanically separated meat, shaped minced meat, proces hygiene criteria*

VARIATION OF THE CHEMICAL COMPOSITION OF RED WINE (*'Touriga Nacional'*) DURING THE FIRST SIX MONTHS OF MATURATION IN NEW AND REUSED OAK WOOD BARRELS

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Abstract

Storage in wood barrels is an important stage in high quality red wines maturation or aging process. In this stage the wine acquires different aromas, enrich the sensorial characteristics and stabilize the colour. Wood specie, their toasting level and the barrel usage (new or used in a second or third maturation process) are key important factors because they are correlated with the wine evolution and consequently with their final quality and aroma profile.
This study aimed to follow the quality variation of a 'Touriga Nacional', Portuguese red wine variety, during the maturation process in French oak barrel produced with wood from Bertranges region. This study was performed during the first six months of the maturation process, in reused and new wood barrel, by sampling each month.
Chemical composition was monitored over time by measuring the acetic acid, alcohol, citric acid, density, fructose, glucose, glycerol, lactic acid, malic acid, pH, saccharose, tartaric acid, total acidity, and total sugars with a Fourier Transform Infrared spectroscopy with Attenuated Total Reflection (FTIR-ATR) in a Bruker spectrometer (Alpha). The equipment used was equipped with a flow-through cell with controlled temperature. The cleaning of the cell was done by the injection of water in the flow-through cell, and the background was also measured with distilled water each ten samples.
To evaluate the differences and interactions between wood barrels and maturation time, a covariance (ANCOVA) analysis, with two factors (barrel [two levels – reused and new wood barrel] and maturation time [six level [one to six months]), was performed. With the analytical data and spectral information collected with FTIR-ATR, a principal component analysis (PCA) were performed to understand the more relevant parameters involved in the maturation process.
The ANCOVA analysis indicated a significant effect for both factors, in which the maturation time account for a higher percentage of variance.
The results showed a quite similar variation of the wine chemical composition during the maturation for new and reused barrel. Though, with the new barrels better results were observed concerning the measured analytical parameters.

Key words: *Red wine, Wine maturation, Oak barrels, Reused barrel*

Funding: This work has been supported by the "Projeto Estratégico de Apoio à Fileira do Vinho na Região Centro" (CENTRO-04-3928-FEDER-000028) and by National Funds through FCT—Foundation for Science and Technology under the Project UIDB/00239/2020 [CEF].

PILOT SCALE MICROBIAL FUEL CELL FOR INDUSTRIAL WASTEWATER TREATMENT

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Abstract

There is a continuous effort in Kuwait to improve wastewater treatment plants and effluent quality by implementing new and sustainable processes in the system. Eight pilot-scale tubular microbial fuel cells (MFCs) have been designed to treat raw industrial wastewater and generate electricity from different industries. The main aim of the study is to investigate and assess the efficiency of MFCs in treating raw industrial wastewater. Industrial wastewater from four main industries in Kuwait (dairy, soft drinks, detergents and petrochemical) was used in this study. The efficiency of the MFCs was examined in terms of maximum power densities, Coulombic efficiencies (CEs), and chemical oxygen demand (COD) removal. The MFCs that operated with detergent wastewater achieved the highest power density 160 mW/m^3, followed by dairy wastewater 55 mW/m^3, and then by soft drinks wastewater 43 mW/m^3. The petrochemical wastewater harmed the microbial community, as low power output was noticed in these MFCs. Regarding treatment efficiency, the MFCs that operated with dairy, soft drinks, and detergent wastewater achieved high COD removal (>90%), however, the removal efficiency for the MFC that operated with petrochemical wastewater didn't exceed 20%. These results show that MFCs can be used in site to treat industrial wastewater (except petrochemical), however, the generated power is a function of industrial wastewater characterization.

Key words: *Microbial fuel cell, Tubular, Industrial wastewater, Treatment efficiency*

PARAMETRIC PROGRAMS FOR 3D MODELING IN THE FUNCTION OF NDT AND DETERMINING LIFE OF PRESSURE VESSELS

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Abstract

Preparation for non-destructive testing (NDT), preparation of test reports, and control calculation of a pressure vessel using the finite element method (FEM), with or without identified irregularities, requires the use of commercial parametric modeling programs. 3D modeling programs enable the determination of the most critical part of the pressure vessel construction as well as the modeling of irregularities after the tests that occurred during the construction, calculation, and exploitation of the pressure vessel construction itself.
Irregularities are reflected in the form of improperly performed welded joints, cracks, corrosion, erosion or cavitation of materials, and are used for the preparation of test reports and control calculations of the pressure vessels construction with and/or without identified irregularities and defects, with the aim of making the correct decision on continued exploitation of the pressure vessel construction or its degree of repair.
The possibility of an unlimited number of views, as well as the possibility of an unlimited number of sections of the entire pressure vessel structure or its part, releases us from creating complicated 2D sketches for the purpose of NDT or control calculation of the pressure vessel FEM structure.
In connection with other computer programs or for the calculation of FEM (fracture mechanics, fatigue), pressure vessel models made in 3D, enable the preparation of a quality test report with the defined traceability and repeatability required by the SRPS ISO/IEC 17025 standard, as well as the making of the correct decision on the exploitation and service life of the structure pressure vessel.

Key words: *NDT, pressure vessels, FEM, parametric modeling, 3D model*

SCREW PRESSES IN THE PRODUCTION OF COLD PRESSED OILS IN "MINI-OIL MILLS"

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Abstract

In the last decades, from 1990s to 2000s, more and more small oilseed processing plants have been built in the Republic of Serbia, so-called "mini-oil mills". In addition to the basic oilseeds: sunflower, soybean and rapeseed, these plants also process other raw materials grown in Serbia, originating from Serbia or imported. These are, for example, naked-pumpkin seeds, flaxseed, sesame seeds, poppy seeds, kernels of walnuts, hazelnuts and almonds, coconut (copra, flour), etc. A characteristic feature of these plants is that they produce almost exclusively edible unrefined (cold-pressed and virgin) vegetable oils and fats, by-products, mainly cakes and various other products based on raw materials and by-products (seeds for snacking, various protein flours, oilseed-based spreads, etc.). Some of these plants process a raw material only to produce crude oil or by-products (such as cake, oil sediment, etc.). The production of cold-pressed oils in these plants is usually done with screw presses. Today, there are presses on the market from different manufacturers, capacities and characteristics, depending on the needs and purposes. The screw press consists of a seed feeder (hopper) for the press feeding, a gearbox (electric motor with a reduction gear), an expeller continuous screw, a barrel with drainage holes and the press head with a hole ring at the outlet (nozzle). Yield and pressing capacity are influenced by: construction and power of the press, oil extraction method, performance, material and construction of individual parts of the press, pressing conditions: material pressure, press head temperature, screw speed (motor frequency). The capacity of the press is often given in the mass of seed that can be processed per hour. Depending on the material being processed, the expected oil production will vary significantly. For example, in sunflower, rapeseed etc., about 1/3 of the seed mass will be produced in oil, while the remaining 2/3 will be cake. Other oilcrops will yield different proportions of oil and cake. Screw presses in "mini-oil mills" typically have capacities ranging from 3 kg to 100 kg of input material per hour. In order to the proper press work, the initial material (oilseeds) must be clean with appropriate moisture content. For the reasons mentioned, changing the raw material also requires some kind of adaptation of the press and pressing conditions in order to obtain the maximum oil yield, without significant increase of production costs and pressing time.

Key words: *cold pressed oils, oilseeds, screw press, capacity, pressing conditions*

EXAMINATION OF THE EFFECT OF REPLACING PART OF WHEAT FLOUR IN MUFFINS ON GLUTENIN PROTEINS

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Abstract

A type of semi-sweet cake which are largely consumed by children, as well as elders are muffins. They are made with wheat flour. The main protein in wheat flour is gluten.
Glutenins are one of gluten' fractions. They are divided into the following fractions: ωb gliadins, HMW and LMW glutenins.
The aim of this paper was to examine the effect of replacing part of wheat flour in muffins on glutenin proteins. Part of the wheat flour was replaced with quinoa. Quinoa is a pseudocereal that is rich in protein, fiber, iron, copper, thiamin and vitamin B6. It does not contain gluten. Muffins are made from wheat flour (100%), then wheat flour with the addition of quinoa (75% wheat flour + 25% quinoa), then wheat flour (50%) and quinoa (50%) and wheat flour (25%) and quinoa (75%). The samples were stored for 0, 2 and 4 weeks. After that, the glutenin proteins was extracted. Extraction was performed with 50% (v/v) 1-propanol to which Tris-HCl (0.05 mol/l, pH=7.5), urea (2 mol/l) and dithioerythritol (1%) was added. Glutenin proteins separation was performed on an HPLC apparatus (Agilent Technologies 1260 Infinity, USA). Absorbance was measured at 210 nm. After the glutenin proteins separation, the total amount of proteins, the amount of protein within the fractions and their relative concentration were determined.
Based on the obtained results, the highest amount of protein was extracted from samples made from wheat flour (100%) and is Xav=27.33, and the lowest from samples made from wheat flour (25%) and quinoa (75%) and is Xav=19.67. During storage time of 0, 2 and 4 weeks, the total amount of proteins decreased and then increased again.

Key words: *muffins, quinoa, glutenin proteins, RP-HPLC*

TRANSIENT THERMAL BEHAVIOUR OF A SUBSTRATE SUBJECTED TO THE ACTIVATION OF AN ELECTRONIC CHIP AND SURFACE COOLING

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Abstract

Controlling the temperature of electronic components is a major interest for electronical industry. Indeed, the lifetime of the components is directly dependent on the temperature levels reached in the electronic boards. Then, it is essential to predict the chip temperature evolution in order to maximize their lifespan. The electronic boards are more and more complex. They are multi-layers composed of different materials. The numerical resolution of the heat transfer equations in these systems requires very fine meshes and therefore very high computation times. It is possible to standardize the characteristics of these multilayer boards in order to treat them as a homogeneous material. The study presented in this work uses this approach and deals with the transient thermal behaviour of a substrate and its chip. The entire surface of the electronic board is cooled by convection. The developed model assumes that the surface convection coefficient is known, constant and uniform. The heat transfer by conduction in the substrate is based on an axisymmetric assumption on the longitudinal dimensions of the exchange surface (r, theta) and an assumption of semi-infinite medium in the transversal direction of the plate (thickness z). These assumptions are verified if on the one hand the activation times of the electronic chips are low enough and the dimensions of the chip is small compared to the electronic board. In these conditions, a fully analytical model is developed considering two successive integral transforms: a Laplace transform for the temporal variable, and a Hankel transform for the radial variable. An explicit expression of the temperature of the surface heated by the component is established, requiring very short computation times compared to numerical simulations. This model can be easily incorporated into a dimensioning code for electronic devices to predict their temperature. It can also be used as a direct model in an inverse procedure for identifying parameters on electronic boards.

Key words: *Analytical Thermal Computation, Cooling of electronic systems, Integral transforms*

INTRODUCTION OF THE INDUCED COUPLED PLASMA (ICP-OES) METHOD FOR THE CHARACTERIZATION OF "GUBER" SREBRENICA MINERAL WATERS

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Abstract

The mineral waters of "Guber" Srebrenica belong to highly mineralized waters with a significant presence of soluble iron. They belong to iron-sulfate waters, which are rich in arsenic, so they can also be called iron-arsenic waters with low pH values. Some of the "Guber" waters of Srebrenica were used for therapeutic purposes in earlier years. Spectrophotometric methods were used for their characterization. Today, instrumental methods are known, which are faster and more efficient for determination. In this work, the Induced Coupled Plasma - Optical Emission Spectrometry (ICP-OES) instrumental method was used for their characterization. Two standards were used to determine the elemental composition of these mineral waters, which differ in concentration and number of elements present. The results obtained by this method for soluble iron from different sources were compared with the spectrophotometric method of iron determination. The obtained results show that the lower iron concentrations in the samples obtained by the ICP method coincide with the results of the spectrophotometric method. However, with high concentrations of iron (Očna voda), the deviations of the ICP method from the standard spectrophotometric method are greater and may be the subject of another paper. There are also discrepancies in the results between the standards regarding lead and arsenic, where higher values occur in samples where standards with a smaller number of present elements were used, which necessitates the use of standard methods.

Key words*: mineral waters, spectrophotometric methods. ICP-OES, soluble iron*

THE IMPACT OF THE SUSPENSION HEATING RATE ON 13X-ZEOLITE CRYSTALLINITY

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Abstract

It is known that the temperature of crystallization during the synthesis of zeolite is one of the most influenced process parameters. However, during the research work on the synthesis of zeolite 13X and the introduction of this material into regular industrial production, it was noticed that the heating rate of the starting reaction mixture can have an equally important influence. This influence can be so pronounced that a difference of just a few minutes in reaching the crystallization temperature can make a significant difference in product quality as well as affect the presence of other phases in the crystal, or even determine the direction of zeolite crystallization.
Therefore, the aim of this research work was to show the influence of the heating rate on the quality of the obtained 13X zeolite powders.
The obtained samples were analyzed in terms of crystallinity, chemical composition, granulometry and specific surface area, and also water and CO_2 adsorption capacities were determined. Additionally, SEM images of the samples showed the morphological characteristics of different 13X zeolite powders. The analyzes results of the obtained powders confirmed the influence of the heating rate and helped to define the optimal synthesis parameters that resulted in stable product quality.

Key words: *cristallinity, heating rate, synthesis, temperature, 13X zeolites*

PRACTICAL RESULTS REGARDING THE USE OF MUSHROOMS IN DAIRY PRODUCTS

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Abstract

The purpose of the study is to present the practical results regarding the introduction of different types of mushrooms in the process of obtaining dairy products.
Edible mushrooms have a multitude of health benefits. They contain a series of nutrients, ensure an efficient digestion, they are very good for increasing immunity. Also, according to some laboratory studies, certain mushroom compounds have the ability to annihilate the development of tumor cells.
In the proposed research, the development of several acid dairy products enriched with edible mushrooms from species found in Romania such as Cantharellus cibarius, Boletus edulis, Pleurotus and Champignon was followed. The developed assortments were compared from a sensorial and physico-chemical point of view with a regular product represented by a dairy assortment in order to note all the aspects that the edible mushrooms brings.
In order to obtain the new assortments, we started from the technology of obtaining acid dairy products with usual additions, and after the seeding process, before the product was packaged, the mushrooms were added in powder form.
Following the determinations made, the obtained results showed that the dairy products enrichment with mushrooms had a positive impact among consumers, the organoleptic analysis showed that consumers are willing to accept the new varieties developed.
From a physico-chemical point of view, in addition to the intake of nutrients and vitamins that mushrooms provide, the developed products performed very well in the laboratory tests, which means that the intake of mushrooms does not change the properties of the ordinary dairy products on the contrary, they helps to improve them.

Key words: *dairy products, edible mushrooms, nutrients, health benefits, organoleptic analysis*

THE INFLUENCE OF THE FERMENTATION PROCESS ON WHITE CABBAGE BIOACTIVE COMPOUNDS – STUDY OF POLYPHENOLS, L-ASCORBIC ACID AND ORGANIC ACIDS

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Abstract

Cabbage (Brassica oleracea) contains an array of phytochemicals that have beneficial health effects. Within this work, polyphenolic component contents, vitamin C content, and organic acids content in cabbage samples were studied, according to the variety of cabbage and technological treatment. White cabbage is also an important vegetable in the human diet mainly due to its contents of bioactive compounds. These compounds, such as polyphenols, minerals, organic acids, or ascorbic acid, show a great abundance in cabbage and exert beneficial effects on human health. The health effects and bioactive capacity of foods depend highly on processing terms like heating, cutting, dehydration, or fermentation. Cultivar ''Futoški'', and hybrid ''Bravo'' cabbage have been subjected to the spontaneous fermentation process. Cabbage heads ''Futoški'' and ''Bravo'' were prepared by removing the 3–4 outer leaves. Fermentation was performed in 50 dm3 plastic barrels, each containing approximately 25 kg of tightly packed cabbage heads. NaCl solution was applied on cabbage heads and altogether was pressed tightly and covered with a plastic film. Polyphenols profile, L-ascorbic acid, and organic acid were determined by HPLC analysis. During fermentation, organic acids become transformed by microorganisms into lactic and acetic acids. After fermentation organic acids content decreased from 2630 to 1130 mg/kg; 746 to 332 mg/kg and 562 to 136 mg/kg for oxalic, citric, and malic acid, respectively. Lactic acid, acetic acid, and other acids generated during fermentation are important for human consumption. During fermentation, hydrolysis of phenolic acids also occurs under the action of enzymatic activity of microorganisms. In this experiment content of polyphenols decrease while the content of kaempferol and catechin increased during fermentation by up to 50%. L-ascorbic acid content decreased during the fermentation process from 32.5 to 14.2 mg /kg in the cabbage sample. Overall analysis shows that the fermentation process leads to significant changes in bioactive compounds.

Key words: *Fermentation, bioactive compounds, polyphenols, organic acids*

THE EFFECT OF ENCAPSULATION ON THE STABILITY, CHEMICAL COMPOSITION AND BIOLOGICAL POTENTIAL OF ELDERBERRY EXTRACT (*SAMBUCUS NIGRA* L.)

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Abstract

Elderberry (Sambucus nigra L.) is the most widespread type of elderberry, which is characterized by nutritionally valuable components that are distributed in all parts of the plant. In this research, fresh elderberry fruits were collected on the territory of Montenegro and lyophilized. Elderberry extracts were obtained by modern microwave-assisted extraction techniques (MAE) by using demineralized water as a solvent for extraction. The obtained extracts were dried by lyophilization for 48 hours to a powder form. For elderberry extract encapsulation two different concentrations of maltodextrin (MD) as a carrier were used (3% and 20%). Obtained elderberry powders were analyzed in the terms of thermal stability, chemical composition, and biological potential. Thermal stability was determined by thermogravimetric analysis. Chemical composition analysis involved determining the content of total phenolics, total flavonoids, total anthocyanins, and total tannins content. Biological activity was investigated using several in vitro antioxidant assays (DPPH - 2,2-diphenyl-1-picrylhydrazyl, FRAP – ferric reducing power, and NO – nitric oxide).
Results of the thermogravimetric analysis showed high thermal protection of elderberry extracts by encapsulation with 20% MD, in contrast to thermally unstable pure elderberry powders. Regarding chemical composition, elderberry powders were distinguished with high content of total phenolic compounds. The elderberry powder encapsulated with 20% maltodextrin had the highest content of flavonoids and anthocyanins (18.21 µg CA/mg elderberry; 49.80 µg C-3-G/mg elderberry, respectively). Besides biological potential, the elderberry powder encapsulated with 20% maltodextrin allso achieved the best antioxidant activity, especially in the reduction potential of Fe^{3+} ion to Fe^{2+} ion (15.17 µg TE/mg elderberry). In this way, it could be concluded that the addition of the carrier has a positive effect on the thermal stability of the elderberry extract, as well as the preservation of its biological potential. The protection of elderberry fruit extracts using encapsulation carriers, gives the possibility of using elderberry in industries in which high temperatures are applied in the production process in order to obtain high-quality products.

Key words: *elderberry extracts, freeze drying, maltodextrin, biological activity*

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CHEMICAL COMPOSITION AND ANTIOXIDANT ACTIVITY OF MARIGOLD (*TAGETES PATULA* L.) AERIAL PARTS ESSENTIAL OIL

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Abstract

The present study aimed to determine the chemical composition and antioxidant activity of essential oil isolated from aerial parts (stem with leaves) of marigolds collected in September 2022, and cultivated in the garden of the village Kruševica (44.3490° N, 20.3994° E), in the municipality of Vlasotince, Southeastern Serbia. The essential oil was isolated by Clevenger-type hydrodistillation, using the hydromodulus of 1:15 m/V. Its qualitative composition was determined by GC/MS and its semi-quantitative composition by the GC/FID method. The antioxidant activity was determined by using the DPPH assay, during 60 minutes of incubation with the radical. The yield of essential oil obtained was 0.124 g/100 g of air-dried plant material. Sixty-six compounds were identified, comprising 99.9% of the total essential oil composition. Monoterpene hydrocarbons (57.0%) were the most abundant group of compounds, followed by oxygen-containing monoterpenes (28.8%), and sesquiterpenes hydrocarbons (8.5%). The phototoxic thiophenes were present only in traces. The most abundant compounds (expressed in relative amounts) were: terpinolene (26.7%), (Z)-β-ocimene (13.1%), and limonene (12.6%). The antioxidant activity of the essential oil studied increased with increasing incubation time with the DPPH radical. The EC_{50} values were 4.69 mg/ml, 3.46 mg/ml, and 2.63 mg/ml after 20, 40, and 60 minutes of incubation, respectively. Although a weak antioxidant (weaker in comparison to synthetic antioxidant BHT, with an EC_{50} value of 0.43 mg/ml after 20 minutes of incubation with the DPPH radical), the essential oil obtained could, due to the presence of terpinolene, (Z)-β-ocimene, and limonene, terpenes with proven insecticidal activity, be used as a potential alternative to synthetic insecticides.

Key words: *Tagetes patula L., aerial parts, essential oil, GC/MS, antioxidant activity*

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COMPARATIVE ANALYSIS OF CHEMICAL COMPOSITION AND ANTIOXIDANT ACTIVITY OF PARSNIP (*PASTINACA SATIVA* L.) AERIAL PARTS AND ROOT ESSENTIAL OIL

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Abstract

The propose of this study was to compare the chemical composition and antioxidant activity of essential oils isolated from fresh aerial parts and root of parsnip grown in Vlasotince, Southeastern Serbia. The essential oils were isolated by Clevenger-type hydrodistillation, using the hydromodulus of 1:10 m/V. Their qualitative composition was determined by GC/MS and their semi-quantitative composition by the GC/FID method. The antioxidant activity was determined spectrophotometrically by using the DPPH assay during 120 minutes of incubation with the radical. Thirty-nine compounds were identified in the essential oil isolated from the aerial parts of parsnip, comprising 99.8% of the total essential oil composition. The dominant group of compounds were phenylpropanoids (59.6%), followed by oxygen-containing monoterpenes (17.6%), and monoterpene hydrocarbons (12.0%). The most abundant compounds were myristicin (59.6%) and linalool (13.8%). Eleven compounds were identified in the essential oil isolated from parsnip root, comprising 99.3% of the total essential oil composition. Phenylpropanoids (94.6%) were the dominant group of compounds, with myristicin as their only representative. Both essential oils' antioxidant activity increased as the incubation time with the DPPH radical was increased from 20 to 120 minutes. The essential oil isolated from the aerial parts showed better antioxidant activity. The EC_{50} values for essential oil isolated from parsnip aerial parts were 5.40 mg/ml, 4.38 mg/ml, 3.88 mg/ml, 3.34 mg/ml, and 2.99 mg/ml after 20, 40, 60, 90, and 120 minutes of incubation, respectively. Regarding the antioxidant activity of the essential oil isolated from parsnip root, the EC_{50} values were 8.77 mg/ml, 7.91 mg/ml, and 7.08 mg/ml, 6.42 mg/ml, and 6.02 mg/ml after 20, 40, 60, 90, and 120 minutes of incubation, respectively. Essential oil isolated from parsnip root should be considered a source of myristicin, a poorly studied alkylbenzene with, according to the literature data, promising therapeutic potential such as antioxidative, anti-inflammatory, antimicrobial, insecticidal, and larvicidal activities.

Key words: *Pastinaca sativa L., aerial parts, root, essential oil, GC/MS, antioxidant activity*

Acknowledgment: This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under the Program of financing scientific research work, number 451-03-47/2023-01/200133. Nataša Simonović is a Scholar of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

KINETICS OF THE CaO-CATALYZED METHANOLYSIS OF OIL BLENDS

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Abstract

Kinetic studies are essential in understanding the influence of certain important reaction factors on the reaction rate so that the obtained data can be used in practice and thus contribute to process improvement. However, so far, in the production of biodiesel from oil blends, the kinetics of the heterogeneously catalyzed methanolysis of oil blends has not yet been investigated. In this paper, to improve the process of biodiesel production, the kinetics of the methanolysis reaction of oil blends consisting of camelina, castor, and used cooking sunflower oils (mass ratio of 30:30:40) catalyzed by CaO was analyzed. The goal was to select an adequate kinetic model for predicting fatty acid methyl esters synthesis at the constant methanol-to-oil blend molar ratio (12:1) and the catalyst amounts from 1% to 5% of the oil blend weight. The catalyst was prepared by calcinating CaO at 550 ℃ for 2 h before use. The methanolysis reaction was conducted in a batch-stirred glass reactor at the reaction temperature of 60 ℃ and under atmospheric pressure. Two kinetic models, a model of pseudo-first-order reaction and a model that include the changing mechanism of the reaction and triacylglycerols mass transfer limitation, were tested. The kinetic parameters were determined using linear analysis. The apparent rate constants of both models increased with the increase of catalyst concentration from 1% to 3%, while the further increase did not significantly affect the apparent rate constants. Although both models were applicable for describing the reaction kinetics, the model with changing reaction mechanism has advantages over the pseudo-first-order model. It predicts the triacylglycerol conversion degree during the whole reaction time and the better agreement between experimental and predicted values of the triacylglycerol conversion degree confirmed by a lower value of the mean relative percent deviation (5.75%, based on the 28 data) than that for the pseudo-first-order reaction model (11.54%, based on the 28 data). In addition, the pseudo-first-order reaction model needs two correlations to describe two periods of reaction, mass transfer and chemical reaction-controlled periods.

Key words: *biodiesel, camelina oil, castor oil, kinetics, methanolysis, used cooking sunflower oil*

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THE EFFECT OF THE OIL BLEND COMPOSITION ON THE METHANOLYSIS REACTION RATE

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Abstract

The commercialization of biodiesel production primarily depends on the availability and price of oily feedstocks. Considering that the quantities of waste and used oils are limited, using their blends with non-edible oils could reduce the uncertainty related to the oily feedstock supply for biodiesel production and, thus, the price of biodiesel. The methanolysis of oil blends consisting of radish and used palm oil over calcium oxide into biodiesel was studied. The goal was to reflect the effect of different oil mass ratios in the blends on the reaction rate and the content of the obtained fatty acid methyl esters. The methanolysis reaction was carried out at the constant methanol-to-oil blend molar ratio (12:1) and catalyst amount (5% based on the oil weight) in a batch reactor at 60℃ under atmospheric pressure. The calcium oxide as a catalyst was activated by calcination at 550℃ for 2 h before use. The used palm oil and radish oil proportions in the oil blends were 90:10, 70:30, and 50:50 (in wt.%). The fatty acid composition of the oils was determined by gas chromatography. Radish oil contains more monosaturated fatty acids (87.0%) than used palm oil (52.1%). Oleic acid was the most abundant monounsaturated fatty acid in both oils (55.0% vs. 52.1%), while a high content of saturated palmitic acid (41.6%) was present in used palm oil. The methanolysis reaction rate was the lowest with the highest proportion of used palm oil (90%) in the oil blend. The increase of radish oil content up to 50% in the oil blend accelerates the reaction and shortens the reaction time to achieve the methyl esters content of over 97%. Therefore, it was ascribed to a higher content of monosaturated fatty acids. Considering the fatty acid composition of the two used oils, their blends can produce biodiesel with good oxidation stability.

Keywords: *biodiesel, calcium oxide, methanolysis, oil blends, radish oil, used palm oil*

Acknowledgments: The present work has been funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Program for financing scientific research work, No. 451-03-47/2023-01/200133. It is also a part of the Project 0-14-18 of the SASA Branch in Niš, Serbia.

APPROACHES FOR EXTRACTING ADDITIONAL VALUE FROM SLAUGHTERHOUSE BLOOD AS A CO-PRODUCT OF MEAT PROCESSING CHAIN

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Abstract

The increased global requirement for proteins as well as for sustainable processing systems urges the development of new and environmentally friendly technologies for recovery and optimal utilization of all by-products, including slaughterhouse blood. Slaughterhouse blood is a significant by-product of the meat industry, and if it is not appropriately discarded, it represents a colossal biohazard. By contrast, slaughterhouse blood has the potential to be collected and processed to generate high-added-value pharmaceutical, food, feed, and petfood ingredients based on its unique nutritive value and exceptional functional properties. Herein, we present a green approach for exploiting slaughterhouse blood erythrocytes as low-cost initial material in fabricating membranes of erythrocytes (i.e., ghosts) as drug delivery systems and hemoglobin (Hb) as cell culture additive. The developed process of gradual hypotonic hemolysis is based and optimized on the specific osmotic properties of erythrocytes from bovine and porcine slaughterhouse blood, could be scaled up to pilot scale level, and employs only low-priced green buffers. This process was evaluated as an encapsulation procedure for dexamethasone sodium phosphate (DexP) into the erythrocyte ghosts. A sustained drug release from DexP-loaded ghosts was shown over 3 days from porcine ghosts and 5 days from bovine ghosts. Hence, DexP-loaded erythrocyte membranes demonstrated a strong possibility for usage as bioderived delivery systems of DexP by mimicking the chemical and structural anisotropic environment of in vivo cell membranes. Providing high hemolysis extent (>90%), the same process allows the isolation of hemoglobin molecules (Hb) free of membrane contaminant after purification by tangential ultrafiltration. Isolated Hb at a concentration of 0.1 μM demonstrated the effect on viability and migratory capacity of mesenchymal stem cells and inhibited and/or modulated their differentiation toward chondro-, osteo-, adipogenic lineages, modulating the expression of specific gene markers. The demonstrated ability of Hb isolated from slaughterhouse blood to modulate multilineage differentiation makes it a potential candidate as a component of cell propagation or preservation media.

Key words: *gradual hypotonic hemolysis, slaughterhouse blood, hemoglobin, erythrocyte membranes, drug delivery systems, mesenchymal stem cells.*

THE PLUM KERNEL OIL METHANOLYSIS IN THE PRESENCE OF THE MENTHOL-BASED DEEP EUTECTIC SOLVENT

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Abstract

The biodiesel production cost can be reduced by using oils obtained from waste kernels and seeds that remained from the production of juices, marmalades, and jams. Using a cosolvent in the methanolysis reaction improves the miscibility of oil and methanol, accelerating the reaction rate and reducing the biodiesel production process. Compared to conventional organic solvents that are most often used as cosolvents in biodiesel production, deep eutectic solvents (DESs) are "green," non–toxic, biodegradable, non-volatile, and eco-friendly. The present paper is focused on the influence of the triethanolamine:menthol (TEOA:M, 2:1 mol/mol) DES on the methanolysis of oil obtained from waste plum kernels by cold-pressing over 35CaO/ZP (35%CaO supported on a fly ash-based zeolite). The reaction was carried out at the following conditions: 60 ºC, the methanol-to-oil molar ratio of 6:1, and the catalyst amount of 6% (based on the oil mass). In addition, attention was paid to the influence of the different amounts of the TEOA:M DES (1 and 9% based on the oil mass) on the conversion rate of triacylglycerols (TAGs) to fatty acid methyl esters (FAMEs). The results were compared with the control reaction (without the presence of DES and the same other reaction conditions). The increase of the TEOA:M amount from 1% to 9%, based on the oil mass, the achieved FAME content in the 30 min of the reaction increases from 82.2% to 98.2%. In the control methanolysis of plum kernel oil, a FAME content of 13.7% was achieved in the same reaction time, while the highest FAME content (95.4%) was achieved within 90 min of the reaction. Also, the separation of esters and alcoholic (glycerol) phase after the reaction completion is much faster in the presence of the TEOA:M DES as a cosolvent (5 min) compared to the control reaction (more than 12 h). The results indicate the potential application of the menthol-based DESs as cosolvents for biodiesel production.

Key words: *biodiesel, deep eutectic solvents, menthol, methanolysis, plum kernel oil, triethanolamine.*

OPTIMIZATION OF THE BIODIESEL PRODUCTION FROM PLUM KERNEL OIL OVER CORN COB ASH

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Abstract

Contemporary research was focused on the potential of converting agricultural biomass and industrial waste into suitable catalysts for biodiesel production. So far, the catalysts obtained by burning palm nuts, walnut, rice, peanut husks, cereals straw, banana peels, etc., have been successfully applied. Also, significant catalytic activity was observed for the ash obtained by burning corn cobs, which was directly applied in biodiesel synthesis or impregnated with NaOH. The present paper aimed to optimize the plum kernel oil methanolysis over corn cob ash. The methanolysis was performed in a 250 mL three-necked glass round-bottomed flask equipped with a reflux condenser and a magnetic stirrer (900 rpm) at 60 °C and under atmospheric pressure. The effect of the reaction conditions (methanol:oil molar ratio, catalyst amount, and reaction time in the range of 9:1-15:1 mol/mol, 10-20% based on the oil mass, and 20-40 min, respectively) on the fatty acid methyl esters (FAMEs) content was investigated according to a 3^3 full factorial design, while the response surface methodology was used to determine the optimal conditions for achieving the highest FAME content. The obtained experimental data of the FAME content were modeled by a second-order polynomial equation, and the analysis of variance (ANOVA) was used to determine the influence of the reaction conditions on FAME content. According to the ANOVA, the catalyst amount had the most significant influence on the FAME content, followed by the reaction time and the methanol:oil molar ratio. The optimal reaction conditions for achieving the maximum FAME content higher than 98.4% were in the following ranges: catalyst amount of 15.0–19.8%, based on the oil mass, methanol:oil molar ratio of 9.7–14.8:1, and reaction time of 29.6–39.1 min. For the lowest methanol:oil molar ratio of 9.7:1, the optimum catalyst amount and time of 18.2% and 36.8 min ensured a predicted FAME content of 98.7%, which was very close to the experimentally obtained value (97.8%).

Key words: *biodiesel, corn cob ash, methanolysis, optimization, plum kernel oil*

INFLUENCE OF PROCESS PARAMETERS ON THE EXTRACTION OF PHENOLIC COMPOUNDS FROM BLACK ELDERBERRY FLOWERS (*SAMBUCUS NIGRA* L.)

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Abstract

The most common type of elderberry is the black elderberry (Sambucus nigra L.), which is distinguished by nutritionally valuable components found in all parts of the plant. The various bioactive components found in elderberries include terpenoids and (poly)phenolic compounds. Many health advantages of phenolic compounds include lower risk of coronary heart disease and stroke, anticarcinogenic activity, anti-inflammatory effects, and immunostimulatory effects. Antioxidant properties of black elderberry extracts have also been demonstrated.
The aim of this study was to measure the amounts of total phenols, flavonoids and anthocyanins in alcohol extracts of black elderberry flowers. The extraction was carried out in time from 30 to 120 minutes with a solid:liquid ratio of 1:15 and 1:30 and with 30% and 60% ethanol as solvent. Total phenolic, flavonoid and anthocyanin contents were measured using the Folin-Ciocalteu reagent, aluminium chloride and the pH differential methods, respectively. The results show that the extraction process has the highest velocity in the first 30 minutes, when the most phenols and flavonoids are extracted, and that the content of these substances increases by only 30% in the following 90 minutes. The highest yields of phenol and flavonoid are achived with a solid:liquid ratio of 1:15 and the use of 60% ethanol, although the acceptable yield is also achieved with 30% ethanol and the same ratio. Furthermore, in the study was established that 30% ethanol cannot be used for anthocyanin extraction of black elderberry flowers because the yield is extremely low.

Key words: *anthocyanins, elderberry extracts, flavonoids, phenols*

COMPETENCE OF THE DOMESTIC LABORATORY THROUGH INTERLABORATORY TESTING OF NATURAL GAS

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Abstract

Natural gas, or compressed natural gas (CNG), is one of the most promising alternative fuels for transport vehicles. Previously, its application was limited to stationary engines, however, with the development of light composite materials for the production of tanks for storing this fuel on vehicles, a much wider application of CNG has opened up, namely on vehicles with engines that have compression ignition or spark ignition.The main constituent of natural gas is methane, which has the highest H:C ratio in relation to the higher hydrocarbons that make up liquid petroleum fuels, and therefore releases the largest amount of heat during combustion, while the CO_2 emission is the lowest. In order to achieve the best ratio between fuel consumption and emissions, it is necessary to achieve an optimal fuel/air ratio, which depends on the engine design, operating conditions and CNG composition. That is why it is very important to know the composition of natural gas, especially the concentration of its main component, methane, when it is used as a fuel for internal combustion engines. The paper describes the procedure for determining the composition of natural gas using the gas chromatography method and ensuring the quality of test results in accordance with the requirements of the international standard ISO/IEC 17025. The results of the verification procedure of the standard method BAS EN ISO 6974-6, the creation of a control chart, the calculation of the measurement uncertainty and the results of the participation in the interlaboratory test in which 70 laboratories from 38 countries participated are listed.

Key words: *natural gas, compressed natural gas, alternative fuel, gas chromatography, measurement uncertainty, control chart*

EFFECT OF COMBINED NON-THERMAL PLASMA/FENTON TREATMENT ON LIGNOCELLULOSE DEGRADATION IN CORN STALKS

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Abstract

Corn is one of the world´s most commonly cultivated crops.A major part of the plant remaining after harvesting is the corn stalk.This corn residueis rich in carbohydrates and could be suitable for the fermentative production of numerous value-added products. The corn stalk's complex structure, recalcitrance deriving from lignin, and high crystallinity and polymerization degree of cellulose prevent conventional pretreatment techniques to separate it efficiently into elementary fractions. Therefore, it is usually processed by burning directly on the ground or landfilling.It seldom can be used for composting or combusted for heat generation. In this study, different advanced oxidation processes were used for the treatment of corn stalks to enable more sustainable valorization of biomass by enzymatic hydrolysis. The effects of non-thermal plasma treatment, treatment with Fenton reagent, and combined non-thermal plasma/Fenton treatment on lignocellulose degradation and biomass digestibility were monitored. Treatment efficacy in terms of degradation was assessed by determininglignincontent. Structural and textural properties of treated biomass were analyzed using FTIR analysis and mercury intrusion porosimetry (MIP).The carbohydrate digestibility estimation was based on hexose and pentose content in hydrolyzed samples. Applied treatments showed success in breaking complex lignocellulose structures. The delignification rates for the non-thermal plasma treated sample, thesample treated only with the Fenton reagent, and the combined non-thermal plasma/Fenton treated sample were 19%, 28.7%, and 53%, respectively. Selectivity towards lignin increased with prolonging the non-thermal plasma treatmentorthe addition of the Fenton reagent.To achieve a delignification rateof 53% by using only non-thermal plasma, treatment should last at least 60 minutes. When the Fenton reagent is added, the same result is obtained with a halved duration of the plasma treatment. Under these conditions, pore size diameter in treated biomass increased, resulting in enhanced biomass digestibility with 2.25 times higher hexose yield compared to the untreated sample. This is a significant step forward in developing sustainable treatments for lignocellulosic biomass, which is especially important in biorefinery processes.

Keywords: *advanced oxidation processes, lignocellulosicbiomass, porosimetry,delignification, biorefinery*

EFFECT OF NON-THERMAL PLASMA TREATMENT ON ANTIOXIDATIVE AND PREBIOTIC PROPERTIES OF AQUEOUS HERBAL EXTRACTS

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Abstract

To provide food with a longer shelf life, synthetic antioxidants are frequently used in the food industry. Common synthetic antioxidants includebutylated hydroxyanisole(BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), and tert-butylated hydroquinone (TBHQ). Since those compounds are suspected to cause some health problems, such as liver damage, there is a strong initiative to develop and utilizeantioxidantsfrom natural origins.Medicinal plants could be a good alternative source of these compounds. Besides antioxidative properties, natural compounds derived from medicinal plants often have various biological activities, like anti-inflammatory, antimicrobial, analgesic, etc.These compounds can contribute to food's functional and technological properties and interact with food microbiota. In this study, aqueous extracts of tea production residues of common nettle (Urtica dioica L.), St. John's wort (Hypericum perforatum L.), and hoary willowherb(Epilobium parviflorum L.) were treated with non-thermal plasma. The effect of different durations of plasma treatment on the antioxidative capacity of these extracts was monitored. The fermentation of these extracts solely and extracts supplemented with MRS broth by Ligilactobacillus salivarius was examined. Antioxidative properties of plasma-treated extracts were analyzed using DPPH and ABTS methods. The total phenol content of these extracts was determined by the Folin-Ciocalteu reagent. Generally, hoary willowherb extracts were rich in total phenol content, two or three orders of magnitude richer than the other two plants. They also showed significantly higher antioxidative activity. This activity slightly decreased with prolonged plasma treatment. However, that didn't affect bacterial growth in these extracts. It was shown that L. salivarius growth was enhanced in the pure plasma-activated extracts of hoary willowherbin comparison to extracts supplemented with MRS broth. Though, the observed effects are substrate-dependent and vary from plant to plant. The antioxidative capacity of common nettle extracts remained intact during the plasma treatment. With the addition of MRS broth (25% v/v), bacterial growth was completely unhindered, providing approximately 10^9 CFU/ml during the exponential phase. Moreover, the 10-minute-long plasma treatment was effective in the inactivation of microorganismsalready present in herbal biomass, preventing the spoilage of treated extracts. This could be an important step up in extraction by hurdle technology, especially in the production of symbiotic preparations possessing both antioxidative and probiotic properties.

Keywords: *common nettle, hoary willowherb, antioxidative activity,probiotics, food, waste valorization*

CHARACTERIZATION OF THYMUS VULGARIS ESSENTIAL OIL FROM VARIOUS LOCAL SUPPLIERS

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Abstract

The medicinal properties of plants have received great interest in food, the pharmaceutical industry, and cosmetics because of their low toxicity, pharmacological activity, and economic viability. The food industry's interest in natural compounds with antioxidant and antimicrobial properties has recently increased. Namely, there is a growing interest in the investigation of new compounds without any adverse effects on human health. Essential oils are aromatic and volatile phytocomplexes obtained from plant material which are composed of different chemical compounds and can be isolated from plants by steam distillation. Thymus vulgaris is a species of evergreen plant in the Lamiaceae family that originated from Mediterranean regions and has been adapted to many climates worldwide. Essential oils obtained from the Lamiaceae family have been widely employed as anti-inflammatory, antiseptic, antifungal, antibacterial, and antiviral agents. These oils may vary greatly due to genetic causes or because of climate and geographical origin thus differing in the biological effects. Due to its strong phenolic profile, thyme essential oil has been used in folk medicine as an antiviral and antimicrobial agent with great digestive and antioxidant properties. In this work, three commercial essential oils from Thymus vulgaris L. (´´Ettera´´, ´´Whole Beauty´´, and ´´Herba oils´´) were analyzed to determine their composition (GC-MS analysis) and biological potential. The thyme essential oil from ´´Ettera´´ is composed of 24 volatile organic compounds with the highest amount of p-cymene (52.09%), thymol (38.15%), and γ-Terpinene (7.36%). The ´´Whole beauty´´ thyme oil consists of 57 compounds, including thymol (33.75%), p-cymene (25.21%), γ-terpinene (7.44%), trans-Caryophyllene (6.97%), carvacrol (3.18%), linalool (2.44%), and α-pinene (2.42%). In the ´´Herba oils´´ 55 compounds are found: the major compound, thymol (42.08%), then p-cymene (25.98%), and carvacrol (5.59%), followed by eucalyptol (5.05%), linalool (4.13%), caryophyllene oxide (2.84%), and camphene (2.14%). All other components were present in amounts less than 1%. The antimicrobial activity of Thymus vulgaris essential oils was conducted on Escherichia coli, Staphylococcus aureus, and Candida albicans, using the microdilution assay. The ´´Ettera´´ MBC/MFC values amounted to 6.25, 1.56, and 3.12 µl/ml, the ´´Whole beauty´´ MBC/MFC were 1.56, 0.78, and 1.56 µl/ml, and for the ´´Herba oils´´, 6.25, 3.12, and 1.56 µl/ml MBC/MFC values were determined, for E. coli, S. aureus, and C. albicans, respectively. The results indicate good antimicrobial activity of all three tested thyme essential oils, with the best antibacterial results obtained for ´´Whole beauty´´.

Key words: *thyme oil, GC-MS analysis, antimicrobial activity*

ENCAPSULATION OF PROBIOTIC STARTER CULTURE IN BIOPOLYMER SYSTEMS USING SPRAY-DRYING AND EXTRUSION TECHNIQUES

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Abstract

In the last few decades, the industry of probiotics and functional foods has been growing due to consumer interest in health and life quality. Probiotics are mostly used with fermented dairy products, pharmaceutical products, and health supplements. The efficiency of added probiotic bacteria depends on their dose level and viability, which must be maintained at a satisfactory level in adverse environments and during the shelf life of the products. Their implementation into functional food products represents a challenge for food technology. Different encapsulation techniques have been successfully utilized to improve the resistance of probiotic culture to production and storage conditions. The unique properties of biopolymers have provided them to be prevalently used for the encapsulation and protection of probiotics in the food industry. But when only one biopolymer is used for encapsulation, it does not exhibit an appropriate effect on encapsulation. A mixture of biopolymers could have the best potential for the encapsulation of probiotics. This study evaluated the efficiency of biopolymer systems (Ca-alginate/whey) for encapsulation of the probiotic starter culture (Lactoferm ABY 6). The encapsulation efficiency was investigated using the enumeration technique and cell release behavior. The carriers were prepared by electrostatic extrusion and spray-drying techniques. The shape and size of the carriers were determined using optical and scanning electron microscopy. The encapsulation efficiency of biopolymer systems was 75.92±0.08 % and 92.39±0.13 %, respectively for spray-drying and extrusion techniques. The biopolymer systems with encapsulated culture were implemented in whey-based beverages and the cell viability was determined after the fermentation and storage time of 21 days. The moisture content, product yield, and solubility of the obtained powder with culture were analyzed. After the fermentation process and the storage time, in the beverage supplemented with encapsulated culture, significantly higher cell viability (> 9,06±0.03 log ($CFUg^{-1}$)) was noted in biopolymer systems prepared using a spray-drying technique. The presence of whey proteins in the systems improved the cell viability during the encapsulation and storage conditions. Our study indicates that biopolymer systems showed good potential as an encapsulating wall material to maintain high cell viability during production processes and storage time.

Key words: *probiotic starter culture, biopolymers, encapsulation techniques, fermented beverages*

EPOXIDATION OF CAMELINA SEED OIL BY *IN SITU* PERACID MECHANISM

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Abstract

By epoxidation of vegetable oils, valuable derivatives are obtained, which can be used in the chemical and polymer industry. Suitable raw materials for epoxidation are highly unsaturated (linseed, soybean, palm, castor, camelina, etc.) oils. The composition of fatty acids in the oil can be significantly depending on the various factors (seed genotype, location, and growing conditions). In this paper, the camelina seed oil of NS Zlatka genotype was chemically modified using epoxidation process to consider its further application. The oil was obtained from the seeds by cold pressing and analyzed by the GC-FID analysis. The analyzed oil was suitable for epoxidation due to the high content of unsaturated fatty acids. The oil epoxidation was performed using the in situ peracid procedure under the following operating conditions: hydrogen peroxide concentrations of 30% (v/v), temperature 45 °C, stirring speed (700 rpm), and reaction time of 4 h. The epoxidation process was monitored based on the change in iodine value, fatty acid composition, and FTIR analysis of the obtained product.

Key words: *camelina seed, oil, GC-FID, FTIR, epoxidation*

FERMENTATION EFFICIENCY OF INTERMEDIATES AND BY-PRODUCT OF SUGAR BEET PROCESSING

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Abstract

Sugar beet is a highly selected crop that accumulates 70% of sugar in the roots, while the other 30% is made up of non-sugars, of which more than 20% are water-insoluble cell walls. The applied processing technology affects the chemical composition of intermediate products and by-products. Therefore, all major global sugar industry concerns pay special attention to regular monitoring of the quality of intermediate production products (juices) and by-products (molasses), whether viewed from the aspect of technological process control or the aspect of an application in fermentation processes.
The intermediate products of sugar beet processing contain fermentable sugars, which can be directly used for fermentation without any additional modification, and compared to all other sources of carbohydrates, very suitable raw materials for the production of bioethanol, both from a technological and an economic point of view.
Based on the above, this research aimed to determine the fermentation efficiency in bioethanol production using the intermediate products and by-product of sugar beet processing. Therefore, the experiments were performed using raw, thin, and thick juice and molasses. Furthermore, since molasses is a traditional raw material for bioethanol production, it was used as a "reference" in analyzing the fermentation efficiency of raw, thin, and thick juice. The intermediate products used to prepare the fermentation medium were diluted with water to the final concentrations of fermentable sugars.
Raw and thin juice were used as fermentation media with the maximum sugar concentration contained in the juice delivered from the factory and with dilutions of 50 and 100 grams of fermentable sugars per liter of fermentation medium. Thick juice and molasses were diluted to final concentrations of fermentable sugars of 50, 100, 150, 200, and 250 g/L. Fermentation efficiency (%) was defined as the amount of consumed fermentable sugars per 100 g of the initial amount of sugar.
With raw juice, the fermentation efficiency has higher values than those obtained with molasses for all three applied initial concentrations of fermentable sugars. The highest fermentation efficiency was achieved using thin juice at an initial concentration of fermentable sugars of 13% (m/v). The fermentation efficiency of a medium with thick juice is significantly higher than that of a medium with molasses in the examined interval of initial concentrations of fermentable sugars from 5 to 25% (m/v).

Key words: *fermentation, efficiency, intermediate products of sugar beet processing, bioethanol*

IN VITRO ANTIOXIDANT ACTIVITY OF COTTON FABRIC TREATED WITH ETHANOL AND WATER *THYMUS SERPYLLUM* L. (WILD THYME) EXTRACTS

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Abstract

The plants contain a large number of various compounds that exhibit significant antioxidant activity. Among them, polyphenols and flavonoids are the most studied compounds with different biological properties, including antioxidant activity. The functionalization of cotton fabric with natural compounds from plants results in the material with improved antioxidative properties. In this study, cotton fabrics treated with ethanol and water Thymus serpyllum L. (wild thyme) extracts were investigated in terms of antioxidant properties and chemical composition. In vitro antioxidant capacity of ethanol and water extracts, and the cotton fabric before and after functionalization was evaluated using 2,2-diphenyl-1-picrylhydrazyl (DPPH$^{\bullet}$), and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS$^{\bullet+}$) radicals scavenging capacity assays. FTIR and UV–Vis spectroscopy elucidated the structure of the cotton fabric, extracts, and functionalized cotton fabric. FTIR spectroscopy demonstrated that the structure of cellulose was dominated in cotton, and also proved the presence of a low percentage of protein, pectin, oil, fat, and wax, as well as, binding of compounds from the extract by cross-linking with long chains of structure cotton. In dry extracts, the presence of various chemical functional groups, was confirmed. UV-Vis analysis identified the active components in T. serpyllum extracts. Namely, absorption values for both spectra (water and ethanol samples) at 215-253 nm, 263-384 nm, are specific for phenolic acids, and flavonoids. Also, one of the aims of the study was to investigate the influence of various extracts (water and ethanol samples) on the antioxidant activity of cotton fabric. All extracts demonstrated excellent antioxidant properties, more potent than the reference antioxidant (ascorbic acid) in both antioxidant assays (between 85-86% in DPPH and 94-96% in ABTS assays). Pure T. serpyllum water extract was the most potent in the DPPH assay (86%), while pure ethanolic extract was the most potent antioxidant in the ABTS assay (96%). The antioxidant capacity of raw cotton fabric was insufficient (4%). On the other hand, in the DPPH assay, samples of cotton fabric with extract showed moderate activity with the scavenging activity of 48% and 45% for ethanol and water extracts, respectively. Additionally, in the ABTS assay, the antioxidant activity of treated cotton fabric was 51% and 46% for ethanol and water extracts, respectively.

***Key words**: Thymus serpyllum extract, cotton fabric, antioxidant activity*

PHYSICOCHEMICAL CHARACTERISATION OF *THYMUS SERPYLLUM* EXTRACTS PREPARED USING NATURAL DEEP EUTECTIC SOLVENTS

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Abstract

Thymus serpyllum L. (wild thyme) extracts were prepared using 1 g of plant material and three natural deep eutectic solvents (30 mL, malic acid+maltose, lactic acid+menthol, or citric acid+glycerol with 50% of water) in maceration (90 min). The extracts were characterized in terms of total polyphenol content (TPC), total protein content, extraction yield, zeta potential, conductivity, pH, density, surface tension, and viscosity. TPC was the highest in citric acid+glycerol extract (35.06±1.13 mg gallic acid equivalents (GAE)/g of plant material), whereas malic acid+maltose and lactic acid+menthol extracts possessed similar TPC (29.62±1.11 and 28.94±1.15 mg GAE/g, respectively). Total protein content amounted to 5.55±0.20 mg/g in citric acid+glycerol extract, while significantly lower values were determined in malic acid+maltose and lactic acid+menthol extracts (1.22±0.30 and 1.73±0.18 mg/g, respectively). The extraction yield was the highest for citric acid+glycerol extract, 1.57±0.11%, followed by malic acid+maltose and lactic acid+menthol extracts, 1.28±0.10 and 1.27±0.13%, respectively. Zeta potential (absolute value, as a predictor of potential application in water treatment) was low in all extracts (0.86±0.06 mV for citric acid+glycerol, -0.35±0.09 mV for lactic acid+menthol, and -0.17±0.05 mV for malic acid+maltose extract). The conductivity (as a predictor of antioxidant capacity) was in the range of 2.35±0.21 and 2.71±0.29 mS/cm (citric acid+glycerol and malic acid+maltose extracts) to 5.70±0.23 mS/cm (lactic acid+menthol extract). pH ranged from 1.44 in citric acid+glycerol extract to 1.78 and 1.85 in malic acid+maltose and lactic acid+menthol extracts. Density varied from 1.067±0.003 g/mL for lactic acid+menthol extract to 1.169±0.002 and 1.195±0.005 g/mL for citric acid+glycerol and malic acid+maltose extracts. Surface tension was the highest in citric acid+glycerol extract (38.0±0.4 mN/m), followed by malic acid+maltose and lactic acid+menthol extracts (31.5±0.4 and 25.9±0.1 mN/m, respectively). The viscosity of lactic acid+menthol extract was significantly lower (1.83±0.30 mPa•s) in comparison to malic acid+maltose and citric acid+glycerol extracts (6.64±0.15 and 7.84±0.10 mPa•s, respectively). The highest TPC, total proteins, and extraction yield were measured in citric acid+glycerol extract, while lactic acid+menthol extract possessed the highest conductivity and the lowest density, surface tension, and viscosity. Therefore, the constitution of natural deep eutectic solvent should be optimized depending on the future application of T. serpyllum extract.

Key words: *Natural deep eutectic solvent, polyphenols, Thymus serpyllum, physical properties*

EFFECT OF POLKA RASPBERRY EXTRACTS (*RUBUS IDAEUS* L.) ON CORROSION INHIBITION OF BRONZE

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Abstract

Plant extracts contain a large number of organic compounds, and one of the large group of compounds present are phenolic compounds. Researches have shown that a certain number of these compounds can be used as effective metal corrosion inhibitors.
Plant extracts of raspberries (leaves, flowers and fruit) were obtained by ultrasonic extraction using 96% ethanol as a solvent.
The UV/Vis spectrophotometric method was used to determine the content of total phenols in plant extracts. Phenolic acids and flavonoids in plant extracts were separated and quantified using the HPLC method. Tafel extrapolation was used for electrochemical characteristics. The corrosion characteristics and behavior of bronze in 3% NaCl solution, with and without the presence of plant extracts were investigated.
The content of total phenols in leaves was found to be 107.14±3.63 mg/g in flowers 148.99±9.02 mg/g and in fruits was 8.75±0.61 mg/g.
Leaf extract in a concentration of 0.04828 g/L according to the Tafel extrapolation method provides the best protection for bronze in a 3% NaCl solution. The same concentration in the case of flower and fruit extracts proved to be the most favorable.

Key words: *raspberry extract, ultrasound, corrosion inhibition, bronze*

THE INFLUENCE OF SELECTED METAL IONS ON THE ADSORPTION OF GLYPHOSATE ON PYROPHYLLITE

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Abstract

The aim of this work, which is a continuation of the research on the adsorption of glyphosate on pyrophyllite, mineral clay from the mine in Parsovići, Konjic, is affected by the addition of various metal ions. Previous tests have shown that glyphosate adsorption is best in a basic medium. The addition of Mn(II), Pb(II), Cr(II) and Ni(II) ions was tested at pH 6, 8, 10, 11 and 12, with pyrophyllite and glyphosate contact time of 60, 120 and 180 min. The influence of each of the mentioned ions on adsorption was tested individually, but also in a mixture. The mass of pyrophyllite used in the adsorption tests is 500 mg, and the volume of the water sample containing glyphosate and added metal ions is 10 mL. Quantification of glyphosate after adsorption was done by spectrophotometric method with ninhydrin. The absorbance of the purple Ruhemann product was measured at 570 nm. Analysis of the content of the tested ions after adsorption was performed by flame atomic absorption spectrometry (FAAS). The influence of selected heavy metal ions will be shown through adsorption capacity (qe), removal efficiency (R) and distribution coefficient (Kd).

Key words: *glyphosate, pyrophyllite, adsorption, spectrophotometry*

EXPERIMENTAL STUDY OF AIR FLOW CHARACTERISTICS IN PACKED BEDS OF SPHERICAL PARTICLES AT ELEVATED TEMPERATURES

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Abstract

Based on the results of the experimental values of the pressure drop at ambient and elevated temperatures, air flow characteristics the in the gas-solid packed beds of mono-sized spherical glass particles was shown. The experiments were performed by measuring the pressure drop across the packed bed of particles (of 0.58, 0.92, 1.04, 1.20, 1.94, 2.98, 3.91 and 4.91 mm diameters) heated to the desired temperature by hot air (of temperatures from 20ºC to 350ºC). The experiments at room temperature were performed using a Plexiglas cylindrical column of a 62 mm diameter and 300 mm height. For the experiments at room and elevated temperature, the thermally insulated packed bed column of a 119 mm diameter and 301 mm height was used. Pressure drop gradient shows typical behavior, i.e. pressure drop value increases nonlinearly when particle Reynolds number increases. Such an increase become more pronounced as bed temperature was raised, for all particle diameters. At a specific value of particle Reynolds number and temperature, the pressure drop gradient increased as particle size decreased. Particularly, at temperature of 100^{o}C, particles of 2.98 mm caused about ten less pressure drop gradient compared to particles of 1.20 mm and about three less pressure drop gradient compared to particle s of 1.94 mm. Very similar trends for temperatures of 200^{o}C and 300^{o}C are evident. The flow of air through the packed bed is dominantly a non-Darcy flow that is generally subject to Forcheimer's dependence. The general trend of the modified pressure drop gradient (defined by Forcheimer) at elevated temperatures is that it increases proportionally with increase in superficial gas velocity at constant particle diameter, and gradually decreases with increasing of particle diameter at some constant superficial gas velocity. In the experimentally range of superficial gas velocities, fluid energy losses during flow through the packed bed are a consequence of significant inertial effects as well. At very low superficial gas velocities the gas flowing is laminar and viscous effects are predominant. Thus, inertial effects are also evident, so it is shown that their importance as well as the importance of viscous effects could be affected by temperature also.

Key words: *packed beds, elevated temperature, spherical particles, pressure drop, non-Darcy flow*

INTEGRATION OF INDUSTRY 4.0 TECHNOLOGIES IN FOOD PROCESSING: A BIBLIOMETRIC ANALYSIS

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Abstract

The concept of "Food Processing 4.0" refers to the integration of Industry 4.0 technologies in food processing in the current digital era. This concept has been gaining increasing attention in the scientific community due to its potential to revolutionize and transform the food sector. In this paper, we review the literature generation trends surrounding the Food Processing 4.0 concept and perform a bibliometric analysis to uncover knowledge development in this area. We queried the Scopus database for scientific articles published over the past decade and examined them according to several bibliometric metrics. The results of the bibliometric analysis indicate that researchers are highly interested in studying the interface between Industry 4.0 and the food sector. Furthermore, the number of publications on this topic has been growing exponentially in recent years. Results this paper presents provide researchers with a better understanding of topic developments and can aid future research by closing present knowledge gaps. Our analysis represents the first bibliometric analysis of its kind in the area of Food Processing 4.0, providing input for up-to-date discussion among researchers and shedding light on emerging trends in this field. Overall, our findings suggest that Food Processing 4.0 is an emerging and promising research area that has the potential to transform the food sector by enabling more efficient, sustainable, and innovative food processing technologies.

Key words: *Artificial intelligence, big data, digitalization, food processing, innovative technologies*

THE IMPORTANCE OF WHEAT CONDITIONING IN THE PRODUCTION OF WHOLE FLOURS

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Abstract

The grinding technique evolved along with the development of mankind and today it has become a real industry. The need to diversify flour assortments has raised the performance of the milling industry and, more than that, the products obtained are of superior quality due to the new machines and techniques for conditioning and grinding. By conditioning we mean the treatment of wheat with water or water and heat. It can be said that, among the technological operations of preparing wheat for mills, conditioning is the one that most influences the technological process of mills, the degree of extraction, the content of mineral substances of the flour, the separation of the germs and implicitly the baking properties of the flour. The essential parameters taken into account in this stage are the moisture content and the degree of hardness of the wheat grain. When determining the degree of extraction, the hectoliter weight has the major impact. Normally, an extraction of over 95% is sought when we talk about wholemeal flours. With the latest generation machines and their control with the help of new technology, 100% wholemeal wheat flours are obtained. The degree of extraction also influences the physico-chemical parameters of the flour and of course the ash content. Enzymatic activity of flour depends on the degree of extraction, wholemeal flour is richer in enzymes than white flour. This difference is primarily due to the distribution of non-uniform enzymes in the wheat grain, starting from the core of the wheat grain to its periphery. Wholemeal flour contains significant amounts of bran and germs, the finer the bran, the darker the color of the flour, so it is important that the bran particles are larger and rarer for the flour obtained from the endosperm to express its characteristics in a way pregnant in the finished product.

Key words: *Wholemeal Flour, Conditionare wheat, Quality*

INVESTIGATION OF THE INFLUENCE OF BIOFUELS ON THE PERFORMANCE OF INTERNAL COMBUSTION ENGINES

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Abstract

The performance of an internal combustion engine can be tested on test circuit, chassis dynamometer and laboratory test benches. Laboratories equipped with test benches are most often used for engine testing because they provide the best accuracy and repeatability of measurement results.The engine testing laboratory of the Faculty of traffic and transport engineering Doboj is equipped with an AVL Dyno perform engine test bench from the renowned manufacturer AVL Austria. The laboratory is equipped with measuring devices and actuators for conducting engine tests according to the ECE R85 standard. Engine performance testing was performed on a VW BKC 1.9 TDI diesel engine. All tests were performed with a biodiesel mixture ratio of 20% m/m in mineral diesel fuel, the quality of which meets the requirements of the BAS EN 590:2018 standard. The paper presents the method of laboratory testing of the engine as well as the measurement results of the dynamic performance of the engine powered by diesel fuel and mixed exhaust diesel and biodiesel fuel.

Keywords*: engine laboratory testing, dynamic engine performance, diesel fuel, biodiesel fuel.*

THE USE OF OAT FLAKES IN WORT AND BEER PRODUCTION

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Abstract

Nowadays, beer is generally produced from barley malt, as the main starch source, although other malted or unmalted cereals are also used in association with or instead of barley malt. These ingredients are called adjuncts and their use can improve and give new organoleptic characteristics to beer. In general, solid adjuncts may have a variety of presentations: whole grain, flour, flakes, roasted or malted cereals. Oats are a popular cereal for human consumption. In medieval times, oats were traditionally used in brewing, but were forgotten when the German purity law was introduced in 1516. Nowadays, use of oats is regaining interest due to their physiological properties. Also, oat has been an alternative gluten-free raw material in the food industry since it contains nearly no gluten. Therefore, attempts have been made to produce beer of good quality using oats, which would be safe for coeliac sufferers. Oats are rich in protein, lipids and β-glucan and consequently lower in starch than conventionally used barley. They have been recommended as an adjunct in brewing due to their higher husk content, which can accelerate lautering. On the other hand, oats contain high amount of lipids, which is negative for head retention. In some beers, such as oatmeal stouts, oat-derived milling products are added as adjuncts and flavoring ingredients. In general, the handling and further processing of fine oat flakes are easier compared with those of oat flour which tends to form lumps.

The objective of this study was to evaluate the possibility of oat flakes application as partial substitute for barley malt in wort and beer production, in a different proportion (10, 30, and 50%), with or without addition of commercial enzyme for wort viscosity reduction – Ultraflo Max (Novozymes, Denmark). With an increase in oat flakes content in the grist, wort viscosity increased, which was corrected with the addition of commercial enzyme. At every ratio, oat flakes had higher wort extract when commercial enzyme was applied, compared to values obtained without enzyme addition. The highest ethanol content was obtained for beer produced with the 10% of oat flakes in the grist (3.68%), when enzyme was applied. Replacement of the barley malt with oat flakes did not have a negative impact on beer fermentation, even at the highest oats flakes content in the grist (50%). Overall, the obtained results indicate that oat flakes had good technological parameters and could be used as a partial substitute for barley malt in beer production.

***Key words**: Oat, Oat flakes, Adjuncts, Beer*

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YEAST CONTRIBUTION TO THE VOLATILE PROFILE OF SAUVIGNON BLANC WINE

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Abstract

The main objective of this study was to investigate the effect of different yeast preparations on the volatile profile of Sauvignon Blanc wine. Two commercial wine yeast preparations (Lalvin MSB™ and SAUVY™, Lallemand, Montreal, Canada) were selected based on their potential to release volatile thiols and enhance Sauvignon blanc varietal character. The commercial strain Saccharomyces cerevisiae QA23 (Lallemand, Montreal, Canada) was used for the control wine sample fermentation. Sauvignon blanc must (22.3 Brix, 5.62 g/L total acidities, and pH 3.6) has been inoculated with yeast preparations according to the producer's instructions and under controlled conditions. The volatile aroma compounds were determined by solid-phase microextraction coupled with gas chromatography (SPME GC/MS), while the concentrations of volatile compounds (expressed in mg/L) were quantified by an external standard method. A total of thirty-one volatile compounds were identified and quantified in wine samples produced by different yeast preparations, while the aroma profile of the wine samples was highly affected by yeast preparation. The majority of the volatile compounds in all analyzed wine samples belong to the group of higher alcohols and esters. Independently of the yeast strain, ethyl oktanoat and ethyl dekanoat were the most abundant volatile compounds which is known for their contribution to the flowery and fruity characteristics. Compared to the control sample, both ethyl ester content was significantly higher in wines fermented by MSB™ and SAUVY™. The concentrations of the 4-mercapto-4-methylpentan-2-one (4MMP) and 3-mercaptohexan-1-ol (main varietal thiols) were significantly higher in wines produced by Lalvin MSB™ (0.28 mg/L)compared to the SAUVY™ (0.22 mg/L) and control sample (0.19 mg/L). The results indicate that selected preparations enhanced the production of the ethyl esters and the varietal thiols when compared to the control wine sample.

Key words: *yeast, wine, volatile profile, SPME GC/MS.*

Acknowledgement: The Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (680-00-00098-2022-02) and the Ministry of Science, Technological Development and Innovations of the Republic of Serbia (451-03-47/2023-01/ 200133).

ANTIMICROBIAL POTENTIAL OF *Teucrium montanum* L. EXTRACTS

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Abstract

Teucrium montanum L. herb or mountain germander is widely used in traditional medicine in the Balkan region. The aim of the paper was to investigate the antimicrobial potential of this plant depending on the solvent used for extraction. The extraction process was performed by standard method from the aerial part of the plant by using water, ethanol, and acetone. Obtained extracts were screened for antimicrobial activity against eight bacterial strains (Proteus vulgaris, Bacillus subtilis, Bacillus cereus, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Listeria monocytogenes and Klebsiella pneumonia), one fungal strain (*Candida albicans) and two moulds (Aspergillus niger and Penicillium sp.). Antimicrobial activity was expressed as minimal inhibitory (MIC) and minimal bactericidal concentration (MBC). All three extracts expressed high antimicrobial activity against all tested microorganisms with MIC values lower than 5 mg/ml. The highest effect was observed against K. pneuoniae with a value of 1.25 mg/ml for all analysed extracts. Additionally, all extracts had higher antimicrobial activity against moulds compared to C. albicans. Use of different solvents did not significantly affect the obtained MIC values. On the other hand, MBC values varied depending on the solvent used for extraction. So, the lowest MBC values of 5 mg/ml were observed for water extract against P. vulgaris and L. monocytogenes and ethanolic extract against P. aeruginosa. MBC values of acetonic extract were equal to or higher than 20 mg/ml for all tested microorganisms. Obtained results indicate good antimicrobial potential of Teucrium montanum L. extracts and create a basis for further research of their use for food or pharmaceutical application.*

Key words: *plant extract, Teucrium montanum L, antimicrobial activity*

Acknowledgement: Ministry of Science, Technological Development and Innovations of the Republic of Serbia (451-03-47/2023-01/ 200133).

THERMODYNAMIC PROPERTIES OF BINARY MIXTURES: EXPERIMENTAL AND COMPUTATIONAL METHODOLOGY

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Abstract

Insight in different types of mixtures' properties has a great impact in understanding and predicting the behavior of mixtures. The properties of liquid mixtures, such as volumetric and transport properties depend on the geometry and steric effects, however, they also depend on noncovalent interactions between molecules. The behavior depends on the functional groups of molecules; the functional groups that were investigated in our work were double bond and -OH group. Double bonds are present in many structures, like fatty acids and have role in many processes, like in polymerization and petrochemical processes. In order to investigate the influence of double bond and -OH group, two sets of mixtures are investigated: (1) n-hexane + 1-hexanol and n-hexane + cis-3-hexen-1-ol and (2) n-octane + 1-hexanol and 1-octene + 1-hexanol. The mixtures are examined experimentally and theoretically. Experimental aspect includes measurement of thermodynamic and transport properties: density and viscosity at the whole composition range at various temperatures, from (288.15 to 318.15) K. Based on the experimental data, excess molar volumes (V^E) and viscosity deviations ($\Delta\eta$) were calculated and for fitting the calculated data the Redlich-Kister equation was used. The theoretical aspect includes two methods: quantum mechanical calculations and simulations with Molecular Dynamic (MD). Quantum mechanical calculations provide information of the intermolecular interactions between two molecules. It also provides information about the geometry and interaction energies between molecules. It is done on model systems representing the influence of the functional groups; double bond and -OH group. Molecular Dynamics is a good tool for connecting the microscopic and macroscopic properties. The MD is based on the solving step-by-step the equation of motion, predicting the dynamics of the system. MD simulations were performed in GROMACS using the simulation time of 2 ns. The combination of experimental and theoretical studies gives a good knowledge on the properties of the mixtures, as well as explanation and understanding of these properties.

Key words: *binary mixtures, thermodynamic properties, density, viscosity, quantum mechanical calculations, molecular dynamic simulations*

THE EFFECT OF ADDING PLANT PROTEINS ON LIQUID WHOLE EGGS PROPERTIES

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Abstract

Eggs are considered as a high nutrient food that can support and sustain human life and growth, it's known for the high content of complete protein which contains all the essential amino acids. Egg protein is found in all parts of eggs, even the shell but very concentrated in egg white (50%) and egg yolk (40%). To extend the shelf-life of eggs and overcome their fragility liquid egg products came as a substitute for shell eggs. Liquid egg products are obtained by shell breaking and separation, homogenization and pasteurization. Due to the pasteurization process liquid egg products are more microbiologically safe and greater safety during storage when compared to shelled eggs. Due to the increase of consumption of liquid eggs, studying their properties and fortifying them to create a new product with higher nutritional value is a need for the current market. Soy and hemp proteins are known to be the most famous plant based proteins. The aim of this study is to evaluate the effect of adding hemp and soy protein to liquid whole egg chemical, physical and microbiological properties. 3,5,10% of both hemp and soy powders were added to whole liquid eggs samples, then samples were homogenized and pH, color and viscosity were measured to evaluate the effect. pH was measured at 4 °C using a portable digital pH meter (206-pH2, Testo SE & Co. KGaA, Titisee-Neustadt, Germany). Tristimulus color measurements were performed with a Konica-Minolta CR-410 chroma-meter (Konica Minolta Sensing Inc., Osaka, Japan) at 4 °C. Viscosity measurement was performed by MCR 92 rheometer (Anton Paar, Les Ulis, France) at 15 °C.

Key words: *Liquid Egg products, Liquid Whole Eggs, Hemp Protein, Soy Protein*

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WASTE TO ENERGY: THE ROLE OF EGGSHELL IN THE PRODUCTION OF BIODIESEL AND PELLETS

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Abstract

Since the use of fossil fuels is one of the main sources of greenhouse gas emissions, the aim is to reduce their use by replacing / adding biodiesel in the transport sector. It was shown that the use of biodiesel emits 11 % less CO and 10 % less polluting particles than when using diesel fuel, and that the net emission of CO_2 is 78 % lower when using biodiesel. Furthermore, the burning of fossil fuels to generate heat leads to the generation of huge amounts of CO_2, NO_x, SO_2 and other pollutants, which can be significantly reduced by using biomass-derived pellets.
Eggshells are solid organic waste that is considered hazardous according to European Commission regulations and is mostly accumulated without any prior treatment. Eggshell is considered to contain 96 – 97 % $CaCO_3$ with 3 – 4 % organic matter, which indicated a huge potential for its revalorization, such as the production of CaO. Biodiesel is produced by the transesterification reaction between higher fatty acids and short-chain alcohol, with the presence of a catalyst, and glycerol is isolated as a side product. Applying the basic principles of the circular economy, biodiesel was synthesized from used cooking oil where CaO obtained from the waste shell of a hen's eggs served as a catalyst. The resulting glycerol can be further used in the production of pellets from waste biomass (lignocellulose). The presented method of biodiesel production is beneficial for the environment in several ways: waste eggshells are removed, waste cooking oil is removed, the resulting glycerine is further used in the production of solid fuel from biomass and biodiesel is produced as a substitute for diesel fuel.
Eggshell was converted to CaO by annealing at 830℃, which was stored under controlled conditions and used as a catalyst in heterogeneously catalysed transesterification of used cooking oil. The thermodynamic characterisation of the obtained biodiesel and crude glycerol was performed by measuring their density and viscosity in the wide temperature range at atmospheric pressure. The obtained results showed that the produced biodiesel meets the requirements prescribed by the European standard for biodiesel.

Key words: *biodiesel, glycerol, waste eggshell, used cooking oil, thermodynamics*

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THE INFLUENCE OF THE pH VALUE OF EXTRACT FROM GRAPE POMACE (*Vitis vinifera L.*) ON THE COLOR INTENSITY OF PRINTED COTTON FABRICS

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Abstract

The aim of this research was to investigate the possibility of obtaining an extract from grape pomace waste, which could be used for antimicrobial printing of textile materials. This approach has a double advantage, on the one hand, the amount of waste in wine production is reduced, and on the other hand, a new product is created that has antimicrobial properties and a positive impact on human health. To obtain a certain spectrum of colors, the pH value of the starting extract of Vitis vinifera L. (pH4.3) was changed in the range from pH2 to pH12. During experiment, it turned out that with a significantly lower concentration of the extract, a greater range of colors can be obtained, but by reducing the concentration, the number of anthocyanins also decreases. Anthocyanins are antioxidants that belong to the flavonoid group and have a positive effect on human health. UV-VIS spectrophotometric color analysis was performed on extract samples with different pH values and the anthocyanin content was determined. Based on the obtained values for absorption and spectral curves, it was observed that the most uniform absorption at wavelengths from 380nm to 540nm is shown by the sample U2-E (pH2). This was confirmed by testing the anthocyanin content at a wavelength of 520 nm. And also, this sample has an intense color that can be visually observed, all due to the Flavylium cation anthocyanin. Grape pomace extract contains large amounts of phenolic compounds, including the listed anthocyanins, flavonoids and tannins, which are known for their antioxidant properties. Research has shown that grape pomace extract has strong antioxidant properties due to the high concentration of phenolic compounds in it. The samples were further used to prepare pastes for printing cotton fabrics. Alginate CHT-NV was used for the preparation of pastes that were further applied to the textile by screen printing. After printing, the color of the resulting paste and the color of the printed prints were analyzed using a diffuse spectrophotometer. The antioxidant and antimicrobial properties of printed textiles were tested against Staphylococcus aureus and Escherichia coli, and the Candida albicans using the agar diffusion method. Based on the results of research on antimicrobial properties, it was established that samples of printed textiles show certain antimicrobial properties.

Key words: *Vitus vinifera L., antimicrobial printing, anthocyanins, color intensity*

VIEW OF INTERACTIONS WITH COHERENT AND INCOHERENT RADIATION FROM THE BIOMEDICAL AND ENGINEERING SIDE, MODELING AND ENGINEERING SOLUTIONS FOR THE SYSTEM, WITH REFERENCE TO THEORETICAL PROBLEMS AND MATERIALS

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Abstract

The decades-long historical background in the application of coherent and incoherent radiation in interaction with materials of organic and inorganic nature, especially in case of the biosphere and human purposes, has developed into many different multidisciplinary branches from their originally independent sophisticated sciences.
The practice, associated with many experimental works and defined procedures, had to be modified in accordance with the branching and connection of the sciences, and sophisticated knowledge was sought in each of them. It was primarily about engineering / medical / pharmaceutical approaches, but help was also sought in many scientific disciplines that were not foreseen.
Life has changed significantly in the last 100 years, with a large gradient of quality growth and an attempt to adapt as much as possible to the rapid development of computer science and it support, and it is flooded with small revolutions that are still debatable, with the boundaries between IV and V industrial revolutions.
Experimental approach to chosen cases of material – target and radiation coherent / incoherent in larger sense are performed. Some theoretical simulations of selected interaction are performed also in presented paper.
Some of our analyses, experimental or theoretical cases are admitted to common applied interactions, and some of them are of potential importance, discussion or for selected applications.

Key words: *coherent radiation, incoherent radiation, modeling, engineering*

THE BLEACHING OF SOYBEAN OIL USING SILICA GEL

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Abstract

Industrial bleaching of edible vegetable oils is performed with commercial bleaching earth of various manufacturers, which has good adsorption characteristics thanks to its chemical and structural composition, textural and morphological characteristics. By bleaching, various impurities and pigments, soaps and free fatty acids are completely removed from vegetable oils, or their content is reduced to the legally prescribed level, and the stability and color of the oil are increased. In the Republic of Srpska, there are significant capacities for the production of silica gel of various granulations, which has a wide range of applications, some of which are based on good adsorption characteristics.

This study focuses on the bleaching of soybean oil using silica gel from a domestic manufacturer and commercial bleaching clay at the following parameters: the percentage of bleaching material (% m/m) of 0.6; 1.1; 1.6 % and 2.1 %, the temperature of 95°C, and the contact time of 30 minutes. After bleaching, the oils were subjected to filtration. The bleaching materials were analyzed in terms of the texture, chemical composition and particle size distribution. To determine the whitening effects of soybean oil with the tested agents, the methods prescribed by the relevant regulation on the quality of edible vegetable oils in Bosnia and Herzegovina were used, which determined the peroxide number, soap content, color, fatty acid composition and free fatty acid content in the oil samples.

The results show that the effects of soybean oil bleaching using silica gel are slightly better than those achieved by commercial clay bleaching when it comes to the decrease in the peroxide number and in the content of free fatty acids, as well as oil loss. Other effects of bleaching soybean oil with these agents are similar, i.e. there is a complete removal of soap, and a slight change in the fatty acid composition and color. Better effects of bleaching with silica gel (change in color and clarity of soybean oil) could be expected by equalizing its granulometric composition with that of commercial bleaching earth. Further research in laboratory conditions should include silica gel with larger granulations, as well as combinations of silica gel with activated carbon, and the results of these studies could be the basis for semi-industrial research on the use of silica gel instead of imported commercial bleaching earth.

Key words: *bleaching effects, commercial bleaching earth, silica gel, soybean oil, characterization*

SWEETENERS FOR REFRESHING NON-ALCOHOLIC BEVERAGES

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Abstract

Increased sugar intake is increased the risk of several medical problems (e.g., obesity, diabetes). Soft drinks are viewed by many as a major contributor to obesity and related health problems. In order to reduce the amount of added sugar, that is, the energy value of the product, some manufacturers use sweeteners. The work aims to identify the means used to sweeten refreshing soft drinks and their impact on the energy value of the product. The paper analyzes the data from the label of 120 samples of refreshing non-alcoholic drinks, from 20 different manufacturers. Selected sales facilities were located in the Šabac. Beverages are divided into categories according to the data on the declaration by Rulebook on quality for refreshing non-alcoholic beverages. Product identification was based on the manufacturer's labeling. The results showed that sugar is used for sweetening in 60.8% of the sample of soft drinks found on the market. Sugars and sweeteners comprise 33% of the sample, and only sweeteners without added sugar comprise 5.8% of the sample. According to the types of refreshing soft drinks, energy drinks and refreshing soft drinks (tonic water, cola soft drink, lemon soft drink) are the ones where only sugar is present most often. Refreshing non-alcoholic drinks with fruit juice are products in which the presence of both sugar and sweeteners was recorded with 55.5%. On average, these drinks have 50% lower energy value compared to products from the same group in which sugar is the only sweetener. The ingredients that give zero-sugar products a sweet taste are only sweeteners. These products, as expected, recorded the lowest energy values. According to the data from the declaration, the most frequently used sweeteners are non-nutritive sweeteners and nine types were recorded in total, while natural sweeteners were not recorded. Steviol glycoside is a sweetener that is present in 33.8% of the sample, followed by sucralose with a participation of 30.6% and acesulfame K 11.3%.
The available data indicate that refreshing soft drinks with sugar, as the main source of sweet taste, are the most represented on our market. Considering the popularity of these products on the market, on the one hand, but also the recommendations of the World Health Organization for controlled sugar intake, on the other hand, there is a need to reformulate these products. Further monitoring of the offer of refreshing non-alcoholic beverages and education of consumers about their composition will continue.

Key words: *sugars, sweeteners, beverages, nutrition, energy value, manufacturer's label*

ULTRASOUND-EMERGING TECHNOLOGY FOR VALORIZATION OF PUMPKIN LEAF BIOMASS: IMPACT OF SONICATION PARAMETERS ON PROTEIN RECOVERY, STRUCTURE, FUNCTIONALITIES, AND BIOACTIVITIES

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Abstract

The potential of food biodiversity and its production streams to generate additional features for isolating high-value products has been underutilized. Even so, the recovery of valuable nutritional compounds like proteins from waste streams and by-products has been identified as a key strategy for enhancing production sustainability in order to open up new market potential. In accordance with those facts, the primary aim of this research was to utilize a relatively novel extraction technique, high-intensity ultrasound, in order to achieve a reduction in time, energy, and extraction solvent consumption while at the same time improving the extraction yield and nutritional value of extracted leaf proteins.For this purpose, an ultrasound probe system with a low frequency (20±0.2 kHz) was utilized to extract the white proteins from the pumpkin leaf biomass, and the effects of different sonication amplitudes (20, 30, 40, 50, 60 and 70%) and duration periods (0, 1, 3, 5, 7.5, 10, 12.5, 15, 17.5, and 20 min) on the yield, solubility and emulsifying qualities, antioxidant properties, and structural characteristics of proteins were studied. In the functional properties evaluated, leaf proteins isolated using ultrasound outperformed those extracted using the conventional extraction method, maceration. High-intensity ultrasound resulted in a slight but gradual decline in solubility with an increase in amplitude, but a significant increase in solubility in an acidic environment was observed with the decrease of cavitation periods.Ultrasound-extracted proteins exhibit nearly 12, 1.5, and 3-fold greater solubility compared to the maceration-extracted sample at pH 3, 4, and 5, respectively. The emulsifying activity diminishes with increasing sonication amplitude and duration but increases in emulsifying stability as sonication periods are extended.The ultrasound extraction provided pumpkin proteins with high radical scavenging activities (i.e., good electron donors) and chelating activity, with half maximal inhibitory concentrations (IC_{50}) in the range of 0.9 to 1.5 mg/ml, and 0.3 to 0.6, respectively, especially at 20 and 40% amplitude. Raman spectroscopy, surface charge, surface hydrophobicity, and sulfhydryl group contents were employed to characterize the structural changes brought on by ultrasound cavitation, and the achieved changes were more influenced by the treatment periods and amplitudes applied. The experimental findings show that the use of ultrasound-emergingtechnology for protein extraction can significantly increase theyield of pumpkin leaf protein by up to 70%. The utilization of leaf proteins in food products and dietary supplements can be augmented by combining the ultrasound periods and amplitudesto create high-value samples with better capabilities.

Key words: *pumpkin leaf biomass, leaf proteins, ultrasound probe extraction, functionalities, protein structure, bioactivities*

Acknowledgment: This research was supported by the Science Fund of the Republic of Serbia, #GRANT No 7751519, Multifunctional leaf protein and assembled nanocarrier structures delivered by enzyme technology–MultiPromis.

EVALUATION OF THE ENERGY POTENTIAL OF BIOMASS AND TEXTILE WASTE FOR REPLACING FOSSIL FUELS IN THE CEMENT INDUSTRY

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Abstract

In Macedonia, the recycling rate is extremely low, representing only 1% of the total generated waste, leading to large amounts of waste being landfilled. A solution in line with the waste management hierarchy regarding waste disposal is waste recovery represented through energy valorization by utilizing the remaining valuable components of waste. In order to avoid throwing waste into landfills which leads to air, soil and groundwater pollution, there is a possibility to use it as an energy source for clinker production. According to the national legal framework, the cement industry is permitted to use different waste types as alternative fuels, including biomass, wood, textile, RDF, plastics, paper, and packaging waste. This work aims to analyze the energy capacity of biomass and textile as alternative fuels and evaluate their potential to replace natural gas as an energy source for cement production, maintaining the necessary operational parameters throughout the process and the set product quality. Motivated by the reduced fossil fuel demand leading to financial savings and lower environmental load, an analysis of different substitution ratios between natural gas and biomass or textile waste was made. The percentage replacement of fossil fuels with alternative fuels varies due to the different thermochemical composition of the wastes considered. Sampling followed by elementary and technical analysis of both biomass and textile was performed before inserting them into the cement kilns. Different substitution ratios were tested with constant monitoring of the operational parameters of the combustion process using instrumentation installed at the plant. Implementing alternative fuels in the cement industry results in a reduced amount of fossil fuels utilized for clinker production, leading to economic savings for the company using each of the proposed waste types. Both biomass and textile waste have shown acceptable parameters for use as additive fuels in cement kilns without affecting product quality. Continuation of this analysis is necessary, as well as expansion to other waste types available on the market containing valuable properties and are in accordance with the predefined requirements of the cement plant for waste applicable as an alternative energy source.

Key words: *alternative fuel, biomass, cement industry, fossil fuel, energy potential, textile waste*

THE XXI CENTURY: THE AGE OF ZEOLITES

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Abstract

Zeolites are used in almost all branches of the chemical industry, they are versatile materials, with a range of applications in a chemical industry. They are crystalline alumosilicates, with a porous structure that can be modified to suit various applications.
In the 20th century, zeolites was used in detergents and catalysis, and the 21st century will be the century in which zeolites will spread to all parts of the chemical industry. The expectations are that zeolites will be leading absorbents, catalysts, that they will play a role in agriculture, to improve soil quality and increase crop yields by apsorbing and slowly realising nutrients, carbon dioxide absorption from industrial emissions and of course in detergents.
Such expectations challenge researchers to find better and more efficient syntheses, to improve existing analytical techniques and to speed up the synthesis of new zeolites. To meet increasing demand for zeolites, researchers are working to develop better and more efficient synthesis methods, as well as imroving analytical techinques to better undestand the properties of these materials. Rapid synthesis of new zeolites is also a key area of research, as it can take long time to synthesize some zeolites using standard methods. Advances in material science and modeling are helping to accelerate the discovery of new zeolites wit specific tailored properties for specific applications. Overall, the versatility of zeolites and their potential for use in a wide range of application make them an exciting area of research in the chemical industry, with significant potential for future growth and innovation.

Key words: *zeolites, adsorption, catalysis*

PHENOL REMOVAL FROM SYNTHETIC WASTEWATER BY ELECTRO-FENTON PROCESS

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Abstract

Water pollution with phenols is a consequence of their massive use in the textile, printing, petrochemical, pharmaceutical, cosmetic and many other industries. Phenols are poisons for protoplasm and its toxic effect is manifested even at very low concentrations. Due to its toxicity and mass production and use, many countries of the world have strict laws regulating the use and transport of phenol. The European Chemicals Agency (ECHA) classifies phenol as a dangerous substance (suspected to be mutagenic), and provides details on the impact of phenol on humans and the environment. There are several methods for removing phenol from wastewater, and the most commonly applied techniques are: chemical oxidation, adsorption, solvent extraction, coagulation and flocculation, reverse osmosis, photocatalysis and electrolysis, as well as advanced oxidation processes. In this research, the electro-Fenton process, as one of the most effective electrochemical advanced oxidation processes (EAOPs) for the removal of organic pollutants in wastewater, was used for the treatment of synthetic wastewater containing phenol as a pollutant. Several process parameters (electrode material, treatment time, stirring; current density, catalyst concentrations) that influence on the efficiency of ·OH generation and phenol degradation were examined. Electro-Fenton process was performed in a batch electrochemical reactor with capacity of 500 cm^3. The concentration of phenol in the waste water was 50 mg/L, and sulfuric acid was used as supporting electrolyte. The results showed the boron dopped diamond anode is significantly more efficient than mixed metal oxides anodes, process is diffusion controlled and the catalyst concentration has impact on the process efficiency. For 180 min of treatment at current density of 2.5 mA/cm^2 a 93.8% phenol removal efficiency was achieved. Specific energy consumption was 29.97 kWh per kilogram of removed phenol, which corresponds to only 3.49 kWh per cubic meter of treated wastewater.

Key words: *wastewater treatment, EAOPs, process parameters, removal efficiency*

THE PRESENCE OF MICROPLASTICS IN THE ENVIRONMENT, SOURCES OF HUMAN EXPOSURE, AND POTENTIAL HEALTH EFFECTS

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Abstract

The characteristics of plastic enable a wide range of applications, therefore society today relies more and more on its use. There are several types of plastic materials, the same are long-lasting and stable. A large part of the used plastics ends up in sanitary and non-sanitary landfills. The disposal of plastics in solid waste landfills is a serious burden on the environment. Namely, some plastic items need several hundred years to fully degrade.The effect of various environmental factors can contribute to the creation of plastic particles, known as microplastics, which can have a harmful effect on the environment and human health. Microplastics represent plastic particles of different shapes and sizes (starting from a few micrometers, even nanometers, to several millimeters), which are created primarily by the partial degradation of coarse plastic, due to exposure to environmental conditions. In addition, microplastics can also be created by the intentional production of small plastic particles for different purposes. Considering the dimensions and properties, microplastics can get into all environmental media (water, air, and soil). Apart from the fact that microplastic particles are harmful in themselves because they are made of different plastic polymers, they can additionally pose a risk because they serve as transporters of other pollutants that can attach to their surface.The exposure pathways can beingestion of water and food, followed by inhalation from the air and contact through the skin. The input of microplastics into the human body can cause potentially harmful and toxic effects on human health. The impact on human health largely depends on microplastics' shape, size, and texture. This paper will present the basic characteristics of microplastics, sources in environmental media, possible routes of human exposure to microplastics, as well as the negative impact of MPs on human health.

Key words: *plastics, microplastics, health effects*

INFLUENCE OF NOISE ON THE QUALITY OF THE ENVIRONMENT IN NOVI SAD

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Abstract

The quality of the environment is defined as a set of natural and created values whose complex interrelationships make up the environment, that is, space and living conditions, and as the state of the environment expressed by physical, chemical, biological, aesthetic and other indicators. Monitoring the state and quality of the environment includes a series of actions aimed at obtaining reliable data on the state and pollution of the environment. Monitoring is carried out by systematic measurement, examination and assessment of indicators of the state and pollution of the environment, which includes the monitoring of natural factors, i.e. changes in the state and characteristics of the environment, including cross-border monitoring, namely: air, water, soil, forests, biodiversity, flora and fauna, climate elements, ozone layer, ionizing and non-ionizing radiation, noise, waste, early warning of accidents with monitoring and assessment of the development of environmental pollution. The goal of this work is to determine the orderliness of the environment through monitoring the environment - specifically the level of noise in the environment, and then propose measures to improve the state of the environment in Novi Sad. Noise measured in the 10 most important places in Novi Sad with the device 2250 Light manufactured by Bruel&Kjaer. When analyzing the results of the noise level measurement from the aspect of the acoustic zones to which the measurement sites belong and the permitted noise levels at the measurement sites MS3, MS7 and MS10, the permitted noise level was not exceeded in any measurement period during the 7 individual days during which the noise level was measured. At measuring point MS5, the permitted noise level was exceeded only in one daytime measuring period, and at measuring point MS6 in 2 nightly measuring periods. At the measuring point MS1, the permitted noise level was exceeded in all measurement periods during the 7 individual days during which the noise level was measured. A high percentage of exceeding the permitted noise levels (for all measurement periods) was recorded at measuring points MS2, MS4 and MS8. At measuring points MS4, MS6 and MS8, the permitted noise level was exceeded in the night period during all 7 days during which the noise level was measured. Proposals for measures to reduce the harmful effects of noise arising from noise sources that were the subject of analysis in this report include the following activities: regular monitoring of the noise level, which represents the starting point for all further analyzes and for all other measures and procedures that need to be taken in order to reduce the noise level and harmful effects, control of the noise source itself, depending on whether the noise is from traffic, construction works, catering establishments, etc., designing residential, residential-business, investment and industrial facilities, small business facilities and city infrastructure with adequate sound protection is of primary importance for protecting people's health from the harmful effects of noise and their undisturbed life and work in a peaceful environment, planning and installation of sound barriers is a significant contribution to noise protection, especially in open spaces, implementation of adopted acoustic zoning of the city territory.

Key words: *environment, noise, monitoring*

APPLICATION OF GRAPE BIOSTIMULATORS AND THEIR STABILITY UNDER SOLAR LIGHT IN RAINWATER

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Abstract

Conventional agricultural production is responsible for much of the world's air, water, and soil pollution. This is due to synthetic fertilizers, pesticides, and herbicides, as well as the burning of fossil fuels for machinery and transportation. These pollutants can have a negative influence on the ecosystem. Organic production is based on the principles of sustainable agriculture, which seeks to produce food in a way that is environmentally friendly and economically viable. Biostimulators are substances that stimulate biological processes in plants. Examples of biostimulators include hormones, vitamins, minerals, enzymes, and other organic compounds. They can be applied directly to plants and help them absorb better and utilize nutrients, increase their resistance to environmental stress, and improve their overall health and vigor. They can also help to stimulate root growth, increase the rate of photosynthesis, and improve the quality of fruits and vegetables. Research on plant biostimulants is gaining increasing attention among scientists. Due to the use of biostimulators, fertilizers can be reduced in the open field and hydroponic cultivation. In this way, the environment is also preserved. Two popular biostimulators are Ormoroc (1-naphtylacetic acid) and Globaryll (6-benzyladenine). Although science has been doing a remarkable job with its efficiency in the field, the information about stability remains vastly insufficient. This study showed that Ormoroc and Globaryll positively affected crop yield. The results showed that the biostimulators were stable under hydrolysis. Only 33.1% of Ormoroc and 8.5% of Globaryll were transformed in 150 days. Further, degradation increased under solar simulator light in ultrapure water and rainwater. The degradation efficiency of Ormoroc was 75% in ultrapure water and 90% in rainwater, while the degradation efficiency of Globaryll was lower, 40% in ultrapure water and 10% in rainwater. The presence of hydrogen carbonates, calcium, magnesium, and chloride ions in rainwater increased the degradation of Ormoroc, as these ions can act as electron acceptors, providing an additional electron transfer pathway for the degradation of Ormoroc. The presence of rainwater ions in the reaction mixture inhibited the degradation of Globaryll, likely due to the formation of complexes between the ions and the substrate. Ormoroc is a carboxylic acid that is easily degraded by hydrolysis. Globaryll has a more rigid structure than Ormoroc, which makes it more resistant to photolysis. The density functional theory study revealed that the degradation efficiency of Globaryll is affected by the presence of different substituents on the benzene ring.

Keywords: *Ormoroc, Globaryll, Grape Yield, Hydrolysis, Photolysis, Density Functional Theory*

PLASMA TREATMENT OF POLLUTED WATER

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Abstract

The presence of emerging contaminants in water is currently a matter of great concern because these chemicals have known or suspected adverse effects on the environment and the human health and they are poorly (or not at all) regulated. Belonging to this class of pollutants, pharmaceuticals particularly worry the scientific community and water treatment stakeholders due to their increasing consumption, their persistence in the environment and the unpredictable effects. Perhaps the most dangerous are antibiotics, their presence in the environment in small concentrations being one of the main drivers of antimicrobial resistance. As conventional treatment techniques fail to efficiently remove these compounds, alternatives are being investigated, such as the advanced oxidation processes (AOPs), based on the production of highly reactive hydroxyl radicals from oxidizing agents such as ozone and/or hydrogen peroxide, sometimes in combination with catalysts and/or UV radiation. Although less studied than the more established AOPs, non-thermal plasma has the advantage of in-situ generation of oxidizing species that react to the pollutant molecules and degrade them. This contribution is intended as an overview of the plasma processes used for degrading pharmaceutical contaminants in water, focusing on three main performance indicators: the compound removal rate, the mineralization and the energy yield. Plasma reactor design will be discussed in connection with the production and transfer of active oxidizing species, as the key to enhancing process efficiency. The most important experimental parameters affecting pollutants removal will also be addressed. The quality of the plasma treated water and the potential for reuse in agriculture will be discussed as well.

Key words: *non-thermal plasma, emerging contaminants, pharmaceuticals, water treatment.*

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UV-FILTERS BENZOPHENONES AS LIGANDS FOR ANDROGEN RECEPTORS- IN SILICO EVALUATION

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Abstract

Benzophenones (BPs) are one of the most known classes of UV-filters. The increased production and usage of UV-filters in the last decade consequently led to BPs ubiquitous presence in the environment and continuous human exposure. Based on the U.S. National Health and Nutrition Examination Survey, BP-3 is omnipresent xenobiotic in the urine of the general population. BP-3 and its metabolite BP-1 are commonly used in personal care products as UV-filters and stabilizers. Considering the potential estrogenic properties, due to the similar structure with oestrogen, different countries urged for additional toxicological studies in order to review the safety of BPs. The aim of this study was to evaluate the binding potential of BPs for androgen receptor. A set of BPs: BP, BP-1, BP-2, BP-3, BP-4, BP-6, BP-7, BP-8, BP-9, BP-10, BP-12, 4-OH-BP, 4-Me-BP, and 2,3,4-OH-BP was tested as potential ligands for androgen receptor using Genetic Optimisation for Ligand Docking (GOLD, version 2020.3.0). Crystal structure of the androgen receptor (PDB entry code 4K7A) ligand binding domain in complex with minoxidil was used. Binding affinities of the analyzed BPs, expressed as ChemPLP fitness scores, were in the range 46.3-71.7 (minoxidil affinity-73.8). The highest score was obtained for BP-12, while BP showed the lowest ChemPLP value. The obtained fitness scores for BP-3 and BP-1 were 50.2 and 54.2, respectively. Further studies that integrate in silico methods with in vitro assays and in vivo animal models are necessary in order to understand potential consequences of exposure to BPs, especially during pregnacy.

Key words: *endocrine disruptors; molecular docking; personal care products; sunscreen creams*

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LEAD AS BIOMARKER OF ENVIRONMENTAL POLLUTION AMONG MALE PATIENTS WITH LUNG ADENOCARCINOMA IN VOJVODINA

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Abstract

Lead (Pb) is widespread used industrial pollutant which causes extensive environmental contamination. Historically, the main source of lead emissions to the air was motor vehicle exhaust due to leaded gasoline. Although lead has been removed from gasoline, air emissions declined, it is present in the soil and can get resuspended into the air. Lead can enter the body after being inhaled or ingested with lead-contaminated food. Once it enters the body, lead is deposited in the bones where it is accumulated. Lung cancer is leading cause of all cancer deaths accounting 1 out of 5 cancer deaths or 1.8 million deaths a year globally. Lead exposure is associated with enhanced risk for lung cancer. In this research 36 male patients (39-84 years old) with inoperable IIIB and IV stadium of lung adenocarcinoma, diagnosed in the Institute for Pulmonary Diseases of Vojvodina, Serbia provided morning urine samples. The presence of lead was determined by ICP-MS in their morning urine samples. In 19,44% (7/36) urine samples Pb was detected above the limit of quantification. The maximal urinary concentration was 14.89 μg/L. In order to take dilution into account the lead levels were expressed in μg/g creatinine and thus the maximal Pb urinary level was up to 90.14 μg/g creatinine. The possible sources of lead emissions today are ore and metals processing, lead smelters, leaded aviation gasoline as well as waste incinerators, utilities, and lead-acid battery manufacturers. It is worthy to note that the highest urinary levels of Pb were found in retired professional driver, while the second highest urinary Pb concentration was detected in retired refinery worker. Despite being removed from gasoline, lead is still an important environmental pollutant that can be associated with lung cancer.

Key words: *pollution; lung cancer; adenocarcinoma; epidemiological study*

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SOURCES OF OUTDOOR POLLUTION AMONG MALE PATIENTS WITH LUNG ADENOCARCINOMA IN VOJVODINA

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Abstract

According to the World Cancer Research Fund International there were 2.2 million new cases of lung cancer in 2020. Non-small cell lung cancer makes about 80% of all lung cancer cases, with adenocarcinoma as the most abundant one. Besides tobacco smoking, environmental causes are the most important factor that contribute the lung cancer development. In this research, 40 male patients (39-84 years old) with inoperable IIIB and IV stadium of lung adenocarcinoma, diagnosed in the Institute for Pulmonary Diseases of Vojvodina, Serbia were enrolled. The patients were asked to fulfil questionnaire regarding their outdoor exposure to environmental pollution. More than half or 55% (22/40) of the interviewed patients reported that live or work in an area with individual wood-burning or gas stove. Industrial pollution sources such as thermal power station, highway, large parking, gas (fuel) station, car wash, factory, incinerator, refinery or landfill were reported by 20% (8/40). Electromagnetic radiation source such as high-voltage power lines, electric substation or cell phone tower was observed near by the permanent address or the working place of 10% (4/40) of the interviewed lung adenocarcinoma patients. An agricultural area or another type of area where herbicides, pesticides or fungicides are applied close to their work or home was disclosed by 12.5% (5/40) of the enrolled patients. The individual stove are the main source of outdoor pollution by which the lung adenocarcinoma patients in Vojvodina are affected, followed by industrial and agricultural pollution, while the electromagnetic radiation is the least abundant source of outdoor pollution.

Key words: *pollution; lung cancer; adenocarcinoma; epidemiological study*

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ARE MICRO-/NANOPLASTICS THE NOVEL GLOBAL HEALTH CHALLENGE?

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Abstract

In the last few decades owning to the wide application and the increased production of plastics, the disposal of plastic waste represents one of the biggest challenges worldwide. It is predicted that in less than 30 years, around 12 000 million metric tons of plastic waste will be on landfills. Microplastics are classified as plastic fragments less than 5 mm in size, whereas nanoplastics are small particles from 1 to 100 nm. Humans are mostly exposed to micro-/nanoplastics (MNPs) by ingestion of contaminated food and water or by air inhalation. However, the indirect rout of exposure to MNPs via personal care products and clothing could not be neglected. Despite the fact that in last few years MNPs were detected in environmental compartments and biota, the investigation of MNPs in human tissues and biological matrices is still a huge obstacle for researchers due to the serious analytical difficulties regarding sample preparation and analysis. The first evidence of the presence of polymeric particles less than 5 µm in human lung tissue suggested that MNPs accumulates in lungs. Particularly concerning is the fact that MNPs fragments were found in all human placenta portions (maternal, fetal and amniochorial membranes). Only recently, MNPs were detected in human urine samples from six volunteers. In another pioneering human biomonitoring study, quantifiable concentrations of MNPs were measured in blood. Additionally, MNPs were measured in the feces of both healthy volunteers and patients with inflammatory bowel disease. Today, based on in vitro and in vivo studies MNPs are recognized as potentially harmful contaminants associated with increased oxidative stress, inflammation, cytotoxicity and even carcinogenicity. Up to now, it is not enough elicited if the particle size or the MNP composition responsible for MNPs toxicity. Scientists are especially concerned about the fact that MNPs act as vector for both plastic additives and environmental pollutants. Appropriate analytical tools and standardized procedures are crucial for obtaining the human biomonitoring data in order to understand the health risk associated with human exposure to MNPs.

Key words: *biological matrix; human health; microplastics; nanoplastics; polymers.*

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RISK ASSESSMENT OF LEACHATE POLLUTION OF THE WATER RESOURCES IN THE SAVA RIVER BASIN

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Abstract

Disposal of waste along riverbeds has been a decades-long problem in FBiH. The problem with pollution of water resources by landfill waters and the removal of waste due to the flooding of landfills located along waterways has a negative effect on the quality of waterways. Research on the impact of leachate on water resources synthetically covered the field of water management and waste management. However, research has shown that this issue could not be adequately addressed primarily due to the lack and/or unsatisfactory quality of input data. Therefore, it is recognised in this paper as a "potentially significant issue" of water management, for which additional research is necessary through the second planning cycle (e.g. field research, preparation of specific research studies and/or collection of additional data) in order to for the relevance and the importance of this issue to be better assessed.

Key words: *Sava river basin, illegal landfills, assessment, pollution load.*

PHENOL REMOVAL FROM WASTEWATER USING HORSERADISH PEROXIDASE IMMOBILIZED ONTO MULTI-WALLED CARBON NANOTUBES *VIA* GLUTARALDEHYDE

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Abstract

Phenolic components present in industrial wastewaters could negatively affect the aquatic ecosystem and human health if they are not properly treated before discharge into waterways. The treatment that can effectively remove phenol from water is a biological process using peroxidases. In the presence of hydrogen peroxide, peroxidases lead to the polymerization of phenol, whereby the resulting polymers are precipitated and thus separated from the water. A significant advantage is achieved when peroxidases are used in an immobilized form on a suitable solid support. In addition to enabling its reuse in several consecutive cycles; the immobilized enzyme is significantly more stable compared to the free enzyme. In this paper, the effectiveness of the application of immobilized horseradish peroxidase onto surface modified carbon nanotubes in the removal of phenol from wastewater was examined. Carbon nanotubes were functionalized with concentrated nitric acid and used as solid support for peroxidase immobilization via glutaraldehyde. A phenol solution in ultra-pure deionized water was used as a model of phenol-containing wastewater. Using immobilized horseradish peroxidase (0.6 U/ml), 82% of phenol was removed after 2 hours of reaction. It can be concluded that bio-catalytic treatment of phenolic wastewater can significantly reduce the content of phenolic pollutants.

Key words: *Immobilized peroxidase, Multi-walled carbon nanotubes, Phenol removal, Wastewater treatment*

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IMPROVEMENT OF POTABLE WATER PREPARATION TECHNOLOGICAL PROCESSES AT THE ILIDŽA SPRING PLANT

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Abstract

One of the most widespread problems affecting people around the world is the lack of hygienically clean water. Water problems are expected to worsen in the coming decades, and water shortages will occur worldwide, even in regions currently considered water-rich. Gračanica municipality is supplied with water from the central, urban water supply system of the settlement of Gračanica and a large number of smaller and larger local water supply systems. It is precisely these smaller local water supply systems that are a problem because they are not adequately organised and supply the majority of the municipality's residents. Such is the case with Ilidža spring in the Soko settlement. The water quality of this spring does not meet the legally prescribed values, therefore, in this paper, the improvement of the technological process of raw water purification is considered with the aim of improving the quality of potable water for the needs of the population and economic activities in the area of Gračanica municipality.

Key words: *plant, raw water treatment, technological process*

CORRELATION BETWEEN ABUNDANCE OF MICROPLASTICS AND CONCENTRATION OF PHTHALATE ESTERS

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Abstract

In the period from 2017 to 2022, 4,500 soil samples from the territory of Vojvodina were analyzed as part of the program for monitoring non-agricultural land. The results showed that the biggest problem was the presence of phthalate esters, which in certain locations were higher than the maximum allowed concentrations. Phthalate esters are plasticizers that are added to plastic products to improve their characteristics. A big problem appears in countries that do not have or do not implement waste management regulations and a large number of plastic products end up in landfills. Phthalates can be washed out from evreday plastic products as well as from plastic films, sewage irrigation, sludge, composting and mulching films used in agriculture and thus end up in soil and water bodies. The next risk is the possibility of the decomposition of plastic products under the influence of environmental conditions (photodegradation, thermooxidative degradation, hydrolytic degradation, and biodegradation by microorganisms). They can be broken down into smaller particles with dimensions smaller than 5 mm, which is by definition microplastics. Given that both polluting substances generally have the same origin it is necessary to quantify the correlation between the amount of microplastics and the concentration of phthalates. This results helped us in the exposure assessment process and in prediction the environmental concentrations of phthalates associated with microplastics in soil which was the goal of this research.

Keywords: *Microplastics, phthalate esters, soil, environment.*

ADSORPTION AND DEGRADATION POTENTIAL OF IMIDACLOPRID INSECTICIDE THROUGH CHEMICALLY MODIFIED CELLULOSE MATERIAL

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Abstract

The extensive use of neonicotinoid insecticides in agriculture has negativ impact on the environment and human health, due to inadequate disposal and their retention in the aquatic environment. Despite this, processes such as photocatalysis and adsorption-desorption have received special attention in the scientific community due to their unique properties and ability to degrade and remove several organic pollutants, including pesticides. This study focuses on the establishment of an efficient two-step technology involving sequential adsorption-desorption, using chemically modified cotton linters with TEMPO radical (2,2,6,6-tetramethylpiperidin-1-yl)oxyl and photocatalytic degradation of the insecticide imidacloprid (IMI) using a TiO_2-based photocatalyst. As a replacement for UVC radiation, a solar-imitated Ultra Vitalux (UV) lamp (300W) was used. Variables such as pH, insecticide concentration, assorbent dose, contact time, temperature, and catalyst concentration were optimized for effective pollutant removal (Co=10 mg L^{-1}). The calculated capacity 27.9 mg g^{-1} IMI using TEMPO-oxidized cotton linters (TOCott), was obtained from Langmuir model fitting at 25 °C followed by efficient desorption giving an acceptable concentration of IMI for photodegradation experiments. Under optimal conditions (0.06 g L^{-1} catalyst), complete degradation of IMI was achieved within 110 min with TiO_2 catalyst. Degradation kinetics follows pseudo-first order. A pseudo-second-order kinetic adsorption model best fits the description of the adsorption of this pesticide. A thermodynamic study reveals that the process of insecticide adsorption on linters was spontaneous and exothermic in nature. Quantum yield measurement and UV-Vis analysis results helped to understand the degradation pathways. The appearance of the fiber surface of the samples before and after sorption was recorded using the scanning electron microscopy (SEM) technique, while the Fourier-transform infrared spectroscopy (FTIR) method was used for qualitative analysis of functional groups and structural characterization of the material.

Keywords: *oxidized cotton, adsorption capacity, pesticides, photocatalytic degradation, environmental protection, TiO_2*

OXIDIZED COTTON FABRIC CHEMICAL FUNCTIONALIZED FOR CATIONIC DAYS ADSORPTION

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Abstract

In the last decades, the rapid development of industrial and agricultural activity caused the release of different organic/or nonorganic pollutants in water, earth and air which lead to a threat to human health and the ecological environment. These pollutants contain toxic heavy metals, organic dyes, pesticides, pharmaceutics and others. Organic dyes are visible pollutants used as coloring agents in, textiles, plastics, paper, food industries, etc. For their removal from wastewater, eco-friendly treatment is needed. Among many process purification, the process of adsorption proved to be an effective method for removing pollutants that are present in water, such as pesticides, dyes and heavy metal ions. Due to the surface charge of polluting substances, the goal is to develop a cheap, efficient, environmentally friendly material. Among them,cotton-based materials can be obtained from various natural sources and can be employed as inexpensive adsorbents. Their adsorption capacities for pollutants can be related to chemical treatment. In general, chemically modified cellulose exhibits higher adsorption capacities for various aquatic pollutants than their unmodified forms.In this aim, oxidized cotton fabric was used in this work, which was chemically modified with citric acid and ethyl lysinate, respectively. In order to activate the surface of the fabric for chemical modification and increase absorption ability, carboxyl and aldehyde functional groups were previously introduced using hydrogen peroxide. Then the cotton fabric is covalently functionalized with citric acid and ethyl lysinate (Co-CA-Et-Lys) and its structure was analyzed by the ATR-FTIR technique. The resulting modified fabric proved to be a good adsorbent for the removal of cationic dyes malachite green (MG)and methylene blue (MB). Its adsorption behavior as influenced by the pH value, adsorption time and initial concentration of various adsorbates were investigated. Based on the obtained results, it was concluded that the adsorption equilibrium was reached after 3h and 1h for malachite Green and methylene blue, respectively. Adsorption kinetics showed that the adsorption rate was well fitted with the pseudo-second-order rate model, and the best adsorption isotherms fitted the Langmuir model. The Langmuir maximum adsorption capacities Co-CA-Et-Lys fabric showed a maximum 152.40 mg/g and 116.2 mg/g for MG and MB, respectively. Compared to other adsorbents based on natural materials, oxidized cotton fabric showed much better sorption properties.

Key words: *Oxidized cotton fabric, chemical modification adosrpion, cationic days*

EFFECT OF THE SYNTHETIC ZEOLITE DOSE ON REMOVAL EFFICIENCY OF HEAVY METAL FROM WASTEWATER

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Abstract

The paper examines the effect of the quantity of synthetic zeolite 4A in the removal efficiency of heavy metals from acid mine drainage. The acid mine drainage was characterized by a low pH value and a high content of suspended solids, sulfates, iron and heavy metals. The pH value of the examined sample was about 3, and the concentrations of the examined metals in the precipitated sample were as follows: Cd - 0.3846 ppm; Pb – 3,355 ppm; Ni - 0.28 ppm; Mn – 184.4 ppm; Cd – 136,651 ppm. The investigation of the effect of the zeolite dose on the efficiency of sorption of heavy metals was carried out by varying ten doses of sorbent in the range from 1 g/L to 17 g/L, in batch conditions, during 2h, at 120 rpm, at room temperature. An increase of the zeolite dose in water induced an increase in the sorption efficiency and a slight increase in the final pH. The final pH increased from 6.2 to 7.7 with increased sorbent dose from 1 g/L to 17 g/L. For all analysed parameters, except for lead, complete removal was achieved at a certain dose of sorbent, while the sorption achieved for lead was close to maximum removal. For Cd, Zn, Mn and Ni, 100% removal was achieved with sorbent doses of 4 g/L, 5 g/L, 7 g/L and 10 g/L, respectively, while in the case of lead with dose of 1 g/L a removal of 98.81% was achieved, and with 7 g/L - 99.7% was removed and this efficiency was maintained despite further increasing the sorbent dose. The maximum load per mass unit of zeolite with Mn, Zn, Pb, Cd and Ni ions was 36, 58 mg, 31.16 mg, 3.315 mg, 0.16 mg and 0.09 mg, respectively. It was achieved for sorbent doses of 5 g/L, 4 g/L, 1 g/L, 2 g/L and 1 g/L, respectively. The achieved sorption capacities followed the sequence: Mn > Zn >> Pb > Cd ≈ Ni, which is in accordance with the initial metal concentration. For all examined sorbent doses, except for the lowest (1 g/L), the maximum capacities were achieved for Mn and Zn ions and the lowest for Ni. This indicates that the high concentration gradient represents a significant driving force contributing to the removal of metal ions. An exception was observed for the sorbent dose of 1 g/L, where the zinc sorption capacity (18.65 mg/g) was slightly higher than the manganese sorption capacity (16.4 mg/g). The maximum loading of the sorbent with the all examined metals was achieved at masses of 4 g/L and 5 g/L and amounted 67.22 mg/g and 64.68 mg/g respectively. At a sorbent doze of 10 g/L, the concentration of analysed heavy metals were below the maximum allowable concentration in wastewater, so this amount of zeolite can be considered as optimal for the treatment of acid mine drainage. Synthetic zeolite 4A can be considered as an effective sorbent for the treatment of acidic mine drainage.

Key words: *Sorption efficiency, sorbent dose, synthetic zeolite, acid mine drainage, heavy metals: Pb, Mn, Zn, Cd, Ni.*

INVESTIGATION ON THE POSSIBILITY OF USING ACTIVATED CARBON FOR COLOR CORRECTION IN THE TREATMENT OF LEACHATE LOADED WITH HEAVY METALS

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Abstract

This research shows the examination of the possibility of using powdered activated carbon "Siha Carbogran FA B533" in the treatment of wastewater loaded with heavy metals. "Siha Carbogran FA B533" is an activated carbon of vegetable origin that is successfully used for color correction in the beverage and confectionery industry. As a representative sample of wastewater loaded with heavy metals, leachate from the tailing of a lead and zinc mine was chosen. The examined water sample was characterized as a slightly acidic to neutral pH value, a high content of suspended matter and sulfate, and a high content of iron, manganese and zinc. The content of iron in the leachate was 54 times higher than the maximum allowable concentration for discharge into surface or underground water, manganese 168 times and zinc 13 times. The influence of the contact time and the dose of used activated carbon was analyzed when determining the efficiency. The results showed that the used activated carbon was not suitable for the sorption of heavy metal ions. However, it was able to lower the BOD_5 of the effluent. All experiments were performed in batch conditions, without adjusting the initial pH value. Speaking of iron and zinc, the contact time and amount of sorbent had no effect on the sorption efficiency and the concentrations of these two metals remained practically unchanged, regardless of the equilibration time and sorbent dose. Regarding the manganese, it was observed a reduction of the initial concentration in about 10% for a sorbent dose of 10 g/L and an equilibration time of 12 h. A further increase in the sorbent dose to 15 g/L did not lead to a significant increase in efficiency regardless of the investigated equilibration time. In general, the application of tested activated carbon did not give sufficiently good results in the sorption of tested metals from real leachates from tailing ponds. The activated carbon did not show significant efficiency in the sorption of heavy metals because of its physico-chemical properties, surface charge and surface functional groups, which was expected. The research also showed that Carbogran FA did not affect the change in the final pH value. This may be another reason for poor sorption results, considering that low pH promotes the mobility of heavy metal ions.

Key words: *Activated carbon, leachate, Fe, Mn, Zn, sorption efficiency*

ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL – BASIC PRINCIPLES AND TECHNOLOGICAL SOLUTIONS

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Abstract

This paper summarizes the basic principles, mechanism and best-known technical procedures for the enhanced biological phosphorus removal from wastewater (EBPR process). All aerobic biological systems for the treatment of wastewater have a natural ability to remove phosphorus, but classic biological treatment procedures often do not give satisfactory results. In order to prevent eutrophication in natural waters, better quality wastewater treatment is needed. This is most often achieved by enhanced biological phosphorus removal methods. EBPR wastewater treatment technology is implemented by changing anaerobic and aerobic conditions in order to enable the accumulation of phosphorus by means of phosphate accumulating organisms (PAOs). These microorganisms have the ability to store more phosphorus than other bacteria naturally present in activated sludge, and their growth is intensified through alternating anaerobic and aerobic zones. Under aerobic conditions PAOs accumulate phosphates by storing polyphosphates as energy reserves in intracellular granules. Previously stored energy in the form of polyphosphate PAOs is used for biomass growth and P release during the anaerobic phase. In this way, phosphorus is incorporated into the biomass that is created during the treatment and subsequently removed through the waste sludge. Thanks to these procedures, biological removal of phosphorus of 80% is achieved. In a wastewater treatment system, the wastewater first enters an anaerobic environment containing readily biodegradable carbon (C) and mixes with the return liquid, followed by an aerobic zone. To start the process, PAOs are mixed with conventional microorganisms. PAOs are specialized for storing and metabolizing P, while conventional bacteria can easily convert biodegradable material from the anaerobic zone into volatile fatty acids (VFA) needed for the process. Under anaerobic conditions, PAOs in the presence of fermentation products assimilate VFA and store them as polyhydroxyalkanoates (PHA), using the stored polyphosphate as an energy source and releasing soluble phosphate anion and cations of magnesium, calcium and potassium. In the aerobic phase, soluble P is absorbed to form cellular polyphosphate, the content of intracellular carbon polymers (eg polyhydroxyalkanoate, PHA) is reduced, and oxidation takes place. Under aerobic conditions, PAOs grow at the expense of stored organic material, using stored C as an energy source to take up soluble orthophosphate and store it as polyphosphate. The best-known technicalprocedures for enhanced biological phosphorus removal from wastewater are: anaerobic-anoxic-oxidative (A2O), Bardenpho, The University of Cape Town (UCT), Johannesburg and Virginia Process (Virginia Initiative Plant - VIP). Both VIP and UCT configurations minimize nitrate recycling in the anaerobic zone, compared to the A2O process, as tests have shown that phosphorus removal efficiency can be adversely affected by nitrate entering the anaerobic zone, especially for wastewaters with low BOD loads. In addition to the high efficiency of phosphorus removal, the EBPR processes are also significant because they represent a good basis for the recovery of phosphorus from wastewater.

Key words: *Phosphorus removal,EBPR, PAO, Removal mechanism, Biosludge,A2O, Bardenpho, UCT.*

INVESTIGATION OF THE EFFECT OF CONTACT TIME ON THE SORPTION EFFICIENCY OF HEAVY METALS FROM WASTEWATER BY SYNTHETIC ZEOLITE

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Abstract

The influence of contact time on the efficiency of extracting heavy metals from acid mine drainage using synthetic zeolite 4A was investigated. The acidic mine drainage was characterized by a low pH value and a high content of suspended solids, sulfates, iron and heavy metals. The pH value of the examined sample was about 3, and the concentrations of the examined metals in the water sample after settling were: Cd - 0.3846 ppm; Pb – 3,355 ppm; Ni - 0.28 ppm; Mn – 184.4 ppm; Cd – 136,651 ppm. The experiment was carried out in batch conditions, with a dose of zeolite of 1 g/L, without adjusting the initial pH value, at room temperature and 120 rpm. The influence of contact time was examined for intervals: 1 min; 5 min; 10 min: 30 min; 60 minutes; 120 min and 24 h. Final pH values after sorption ranged between 5.1 and 6.1 independently on the equilibration time. The change in contact time had different effects on the efficiency of metal sorption, depending on the observed metal and the initial concentration. The sorption efficiency of lead, manganese and zinc ions was quite independent of the contact time, but influenced on the initial metal concentration. For lead, manganese and zinc, equilibrium concentrations were reached in a very short time and the process was almost completed in the first minutes. The sorption efficiency of lead ion ranged from 91.06% to 96.95%. The highest efficiency was obtained after 24 h (97%), however for the rest of analyzed contact time the efficiencies were approximately similar (~ 95%) and close to the maximum value obtained. The sorption efficiency of cadmium ion ranged from 22.3% to 52.86%. The the highest efficiency was obtained after 24 h (52.86%). After 120 min, the efficiency was close to the maximum obtained value and amounted to 48.36%. Speaking of nickel, the highest efficiency was achieved after 10 min (66.79%). Extending the contact time caused decreasing in the efficiency (from 65.85% to 58.46%). The efficiencies up to 120 min were close to the maximum the obtained value. Sorption efficiencies for manganese and zinc ions are significantly lower compared to other metals and ranged from 5-8% for manganese and 7-10% for zinc. However, the sorbed amounts per gram of sorbent are significantly higher for these two metals and ranged from 8.14 mg/g to 14.82 mg/g in the case of manganese and 9.18 mg/g to 13.45 mg/g in the case of zinc. Regardless of the type and concentration of sorbate, we can consider that a time of 2h is sufficient to establish equilibrium. The achieved efficiencies and sorbed amounts after 2h of contact followed the sequence: Pb >> Ni > Cd >>Zn > Mn, and Zn > Mn > Pb >> Cd ≈ Ni, respectively. From all of the above, it can be concluded that synthetic zeolite 4A shows good uptakefor heavy metal ions from wastewater.

Key words: *Sorption efficiency, contact time, synthetic zeolite, acid mine drainage, heavy metals: Pb, Mn, Zn, Cd, Ni.*

DETERMINATION OF HEAVY METAL CONTENTS IN STINGING NETTLE FROM DIFFERENT LOCALITIES IN SERBIA

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Abstract

The stinging nettle (Urtica dioica L.) belongs to the Urticaceae family and represents a perennial plant. Stinging nettle is abundant species occurring in various types of forest, road verges and grassland sites. In many countries is used as both medicine and food. Stinging nettle is a weed and its seeds, leaves and even roots are used for medicinal purpose. Thanks to its high content of nutriments and bioactive compounds like poly phenols, vitamins and minerals, nettle possesses a great nutritional value and a large number of pharmacological effects, including anti-proliferative, anti-inflammatory, antioxidant, analgesic, immunostimulatory, anti-infectious, hypotensive, antiulcer activities and cardiovascular disease prevention. It is a reservoir of minerals (especially iron), vitamin C and pro-vitamin A. Last decades the popularity of herbal medicine is rapidly increasing all over the world. However, heavy metal toxicity in plant materials has a great impact and importance on herbal plants and consequently affects the quality of herbal raw materials, herbal extracts, the safety and marketability of drugs. This paper presents determination of content seven heavy metals (Cu, Fe, Mn, Ni, Zn, Cd and Pb) in leaves samples Urtica dioica L. collected from five localities in Republic of Serbia. The sample preparation procedure involved dry digestion in triplicate and dissolution of the ash in 6M HCl and then in 0.1 M HNO_3. All elements were analyzed using an inductively coupled plasma-optical emission spectrometry (ICP-OES). The contents of Ni, Cu, Zn, Mn and Fe in the leaves were found to be in the ranges of 0.54±0.00 to 1.87±0.10 < 2.12±0.69-12.79±0.53 < 18.18±0.46-28.48±1.37 < 30.63±1.45-68.44±5.11, and 109.75±4.01-244.41±13.50 mg/kg dry weight, respectively. Value of toxic heavy metal Pb in two samples is 0.37±0.0 mg/kg dry weight, whiles content Cd has been below the detection limit. The content of heavy metals in samples were used to calculate target hazard quotients values (THQ) and hazard index (HI).

Key words: *Urtica dioica L, trace elements, heavy metals, Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES).*

IMPROVING SOLID WASTE MANAGEMENT AS IMPORTANT STEP TO SUSTAINABILITY: SEPARATION OF WASTE IN HOUSEHOLDS

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Abstract

Waste management is still a global challenge in the 21st century. Sustainable waste management aims to minimize the amount of solid waste that goes to landfill, keep materials in use as long as possible and thus ensure a reduction in the negative environmental, social and financial impacts of consumption. Household waste management is a challenging task because of the increasing amount of waste globally and the large quantity of different materials in this waste stream. Sorting the waste at the source, the place where it is generated, is a crucial task to promote recycling and circular economy. Primary separation of municipal waste in the Republic of Serbia is determined by the law on waste management and separate collection of plastic, paper, glass and metal is foreseen. However, waste sorting is still not a popular practice in households. Waste sorting at the source presents an initial step to recycling. This paper describes the primary separation of household waste in the urban area of Šabac, which is a part of project "Supply of equipment for solid waste source separation schemes in 4 regions". The project is implemented in four regions for waste management and include a total of seventeen cities and municipalities in Serbia. With the participation of citizens, the city of Šabac has started a project of primary waste sorting in households. Households were able to pick up bins for the primary sorting of household waste, as well as brochures with instructions. In the bins, citizens separate paper, plastic and metal waste from their households, which will later be used in the recycling process. By introducing the primary selection of household waste in this way, it is expected that the rate of recycling will increase to 15% in the next 2 years. In this way, goals such as: reduction of landfilled waste, preservation of the capacity of the Srem-Mačva sanitary landfill, contribution to recycling which results in saving energy, natural resources and money, preserves the environment, which is in accordance with the principles of sustainable development.

Key words: *waste, household waste, waste sorting, Šabac, sustainable development.*

POLLUTANT CLASSIFICATION IN THE NORTHEASTERN PART OF PODMAJEVICA

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Abstract

According to the latest classification from 2022 (Amruta P. Classification of Pollutants - Environmental Notes. Prep.in. 2022), which identifies the eleven most common types of pollution, the objective was to identify the types of pollution present and locate them in the northeastern part of Podmajevica (Air pollution, Water, Light pollution, Noise pollution, Plastic pollution, Soil contamination, Electromagnetic pollution, Radioactive pollution, Thermal pollution, Visual pollution, Waste). As expected, the Ugljevik Thermal Power Plant was confirmed as the dominant source of air pollution, while the basic parameters of NOx, NO_2 and NO in the range from 0 ppm to 0.1/0.2/0.5/1.0 ppm, O_3 range from 0 ppm to 0.1/0.2/0.5/1.0 ppm, SO_2 range 0 ppm to 0.05/0.1/0.2/0.5 ppm, as well as CO range 0 ppm to 10/20/50/100 ppm. were monitored. 110METEX00 UZ (- 40 to + 60) [^oC], pressure (825 to 1050) [hPa], and relative humidity (0 - 100 [percent] were used for microclimatic characteristics. The data were processed using the software 110IOVISA00 IOVIS (HORIBA). The paper shows the average amount of pollution that TE Ugljevik will put into the air each day during the year 2022. Buildings with individual combustion engines, i.e. households that are seasonal air polluters, with an average release of 1,340 kg of CO_2 per heating season, or 44,6 kg of CO_2 per day, were identified as the second largest polluters. The analysis of soil samples from the Pirkovci and Makovac sites revealed that the soil was not contaminated with heavy metals and that agricultural land was not polluted, while the PAH content in the soil samples was below the limit value. Automobiles, which according to recalculated standards emit 3.10 kg of CO, 1.86 kg of hydrocarbons, and 0.155 kg of ppm per day, are among the largest mobile air polluters. There was no detection of radioactive, electromagnetic, noise, or light pollution. In the pre-election period, visual pollution is caused by the excessive posting of posters. In order to preserve the environment, it is crucial to detect and locate potential pollutants so that appropriate measures can be taken to reduce environmental contamination.

Key words: *pollutant classification, air pollution, SO_2, CO_2, CO*

MECHANISM AND PARAMETERS OF THE EBPR PROCESS

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Abstract

The mechanism and parameters of the process for improved biological removal of phosphorus are analyzed in this paper. Phosphorus,involved in the main physiological processes of living systems, is an essential chemical element for the entire living world on Earth and one of the most important biogenic elements in it. Due to its extreme reactivity, phosphorus is widely distributed in many minerals, as well as in living organisms. Most of the world's phosphate production is used in agriculture, in the fertilizer industry, in the production of pesticides and as an additive in animal food. In general, phosphorus occurs widely in wastewater, where it appears in several forms, such as: orthophosphate, phosphate, polyphosphate, organic phosphate ester and organic phosphonate.The only form of phosphorus that can be used by bacteria, algae and plants is orthophosphate. Therefore, for the biological removal of phosphorus, it is necessary to convert all the listed forms of phosphorus into orthophosphates so that phosphorus can be removed biologically from waste water. The removal of phosphorus from waste water is primarily conducted in order to control eutrophication, because phosphorus is the limiting nutrient in most water systems. Phosphorus can be removed by chemical and biological treatment or a combination of both processes. Biomass produced by cellular growth of heterotrophic bacteria can remove only 10-20% of phosphorus in municipal wastewater treatment. Although, since the late 1970s by designing plants that use phosphorus-accumulating bacteria, called phosphorus-accumulating organisms (PAOs), biological removal of 80% of phosphorus has been achieved, and the processes are called enhanced biological phosphorus removal (EBPR). Enhanced biological phosphorus removal involves the incorporation of phosphorus into the biomass produced in the treatment system and its subsequent removal through waste sludge. The basic mechanism of the EBPR process is based on the use of a reactor consisting of an anaerobic and an aerobic pool, where phosphorus-accumulating organisms (PAOs) have an advantage in growth and phosphorus consumption compared to other bacteria. Phosphorus-accumulating organisms have the ability to transport and consume easily biodegradable HPK in the form of volatile fatty acids (VFA), using the energy obtained from stored phosphorus and polyphosphate. (PAO) form very dense follicles that accumulate to produce sludge, and the release rate of phosphorus from active sludge is usually faster than rate of adoption of phosphorus in the EBPR process. Phosphorus is removed from waste water, by throwing out excess sludge rich in polyphosphates. The basic parameters that affect the efficiency of the process are: temperature, pH, content of acetate and propionate. At temperatures of 10^{o}C and below, phosphorus accumulating organisms are largely favored over others, while temperatures between 20 and 30^{o}C are more suitable for other organisms compared to (PAO). A pH value between 7 and 7.5 is the most optimal and favors the growth of phosphorus accumulating organisms (PAO). They are also capable of using acetate and propionate for greater process efficiency. It can be concluded that the EBPR process shows good efficiency in removing phosphorus from wastewater. The advantages of the EBPR process are primarily low prices and high efficiency.

Key words: *EBPR, removal mechanisms, pH, temperature.*

CEMENT PRODUCTION INDUSTRY: IMPACT ON AMBIENT AIR QUALITY

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Abstract

Cement is one of the most widely used binders in the construction all over the world.The main environmental issues associated with cement production are emissions to air and energy use. Cement air pollution is rapidly becoming an environmental problem of public concern worldwide.Moravacem is one of the three cement production plants in the Republic of Serbia. Moravacem cement plant is located in central Serbia, in the village of Popovac, near the town of Paraćin. In this paper, average concentrations and time and seasonal variations of particulate matter (PM_{10},$PM_{2.5}$ and PM_1) and gaseous pollutants (SO_2, NO_2, NO, NO_x, CO, O_3) measured at the automatic air quality monitoring station Popovac in the period from December 2020 till January 2023 were analyzed. The daily mean concentrations of PM_{10}, $PM_{2.5}$ and PM_1 were 49.2, 22.6 and 17.3 μg m^{-3}, with maximum daily mean values of 171.1, 87.4 and 83.0 μg m^{-3}, respectively.Concerning the particles size distribution in the mass concentrations, $PM_{2.5}$ on average counted for about 52% of PM_{10}. The highest mean concentration of $PM_{2.5}$ and PM_1 was measured during the winter period (28.9 and 24.8 μg m^{-3}), followed by autumn, spring and summer with the lowest measured mean concentration (15.2 and 9.1 μg m^{-3}).The highest mean concentration of PM_{10} was measured during the spring (55.5 μg m^{-3}), followed by autumn, winter and summer with the lowest measured mean concentration (43.7 μg m^{-3}). According to European Regulation (EU Directive 2008/50/EC) the daily limit value for PM_{10} is 50 μg m^{-3}. During the observed period from December 2020 to January 2023, the measured daily mean concentrations of PM_{10} at the Popovac station were above 50 μg m^{-3} for 255 days (34.7% of the time). When the mean daily concentrations for PM_{10} are compared with WHO recommendations, the number of days with exceedances of the recommended value of 45 μg m^{-3} was 312 days (42.5% of the time). Measured daily mean concentrations of $PM_{2.5}$ were above the values recommended by the WHO Air Quality Guidelines (AQG) (15 μg m^{-3}) for 590 days (80.4 % of the time).

Keywords:*PM_1,$PM_{2.5}$, PM_{10}, gaseous pollutants, cement production industry, Popovac.*

ECO-SUSTAINABLE GREEN REMEDIATION: POTENTIAL OF DANDELION (*TARAXACUM SP.*) IN REMEDIATION OF SOIL CONTAMINATED WITH HEAVY METALS

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Abstract

Soil quality is a key factor for meeting all the needs of human life and environmental health, and because of that the restoration of contaminated soil is essential for regaining biodiversity and ecosystem services, and thereby for achieving the United Nations Sustainable Development Goals (UN-SDG). Due to urbanization, industrialization, agricultural activities and population growth, the soil is contaminated with a large number of harmful pollutants that significantly reduce its quality. Soil remediation and soil management are important issues worldwide to ensure soil function, with the role of green technologies in soil remediation being vital and providing numerous benefits towards environmental sustainability. Phytoremediation is a technique that is accepted worldwide as the most eco-friendly and cost-effective method for soil remediation. It is represents a promising tools for the decontamination and restoration of ecosystems in a sustainable manner with minor impact on biodiversity. This technique is especially suitable for the removal of heavy metals from polluted soil. The continuous accumulation of heavy metals in the environment poses a significant threat to the health of biota, including humans, which undoubtedly undermines global initiatives for environmental sustainability. To date, about 450 heavy metal hyperaccumulating species have been identified, and one such reported hyperaccumulating plant is dandelion (Taraxacum sp). The advantage of using dandelion is that it is a common wild plant species which has the ability to tolerate a wide range of environmental conditions, it does not need to be sown, and it can be mowed several times a year. The aim of this paper is review of the most important results about using dandelion for removal of heavy metals from polluted soil.

Keywords: *polluted soil; heavy metals; phytoremediation; dandelion.*

CENTIPEDES (CHILOPODA) AS BIOINDICATORS OF SOIL POLLUTION

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Abstract

Bioindicators have proven to be a useful tool for monitoring and detecting changes in the environment. Since canaries were used to detect carbon monoxide in mines, the use of indicators has expanded to aquatic and terrestrial ecosystems, covering a wide range of habitat changes, from local disturbances to global climate change. A bioindicator can be broadly defined as a species or group of species that reflects the abiotic or biotic state of the environment, represents the effects of environmental change on a habitat, community, or ecosystem, or indicates the diversity of other species. A good bioindicator should have known taxonomy and ecology, be distributed over a large geographic area, be specialized for specific habitat requirements, provide early warning of change, be easy and inexpensive to collect, be relatively independent of sample size, its response should reflect the response of other species, one should be able to distinguish between natural cycles or trends and those caused by anthropogenic influences, and it should be of potential economic importance. Because of the wide range of desired characteristics, it is difficult to find species or groups of species that have all of the above characteristics. Some invertebrate species are known to efficiently accumulate heavy metals. In general, the accumulation of metals by such organisms is based on efficient detoxification mechanisms, such as intracellular compartmentalization or metal inactivation by binding to metallothioneins. The aim of this study is to determine the suitability of local centipede fauna as bioindicators of soil pollution. Centipedes (Chilopoda) are an important group of predatory arthropods in many terrestrial habitats. They include about 3150 species found from north of the Arctic Circle to the desert fringe in soil and leaf litter or under stones or bark. Previous studies have shown that centipedes can serve as suitable bioindicators of heavy metal exposure. For example, Lithobius variegatus *had significantly higher copper concentrations in contaminated woodlands, while the same species collected from sites polluted by smelters contained large amounts of zinc. In addition, cadmium was accumulated in urban areas by* Eupolybothrus transsylvanicus *and* Clinopodes flavidus *in very high concentrations, while* Cryptops anomalans *can be considered as a bioindicator of zinc. To date, 50 centipede species have been identified in Republic of Srpska, many of which meet the requirements that a helpful indicator species should have. We believe that the use of centipedes as bioindicators of heavy metal pollution should become the standard method for studying the effects of external factors on an ecosystem and its development, and for distinguishing between polluted and unpolluted areas.*

Key words: *centipedes, bioindicators, soil pollution, heavy metals, Republic of Srpska.*

PLANT MEDIATED SYNTHETIZED NZVI SUPPORTED ON BIOCHAR IN THE TREATMENT OF DIFFERENT ENVIRONMENTAL MEDIA

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Abstract

Large amounts of hazardous substances have already been generated through anthropogenic and industrial processes and are found in the soil, water, and sediment. Despite the fact that there are many different techniques available for removing organic contaminants like polycyclic aromatic hydrocarbons (PAHs), nitro explosives, and halogenated organic compounds, heavy metals (HMs), and macronutrients like nitrates (NO3), nano zero-valent iron (nZVI) has been recognized as a promising material. The application of nanotechnologies in environmental remediation processes has been constantly increasing over the years due to low treatment costs and constant improvement of the quality of applied remediation processes. The most frequent method for producing nZVI is to reduce Fe_2 or Fe_3 with borohydride. The borohydride reduction process, however, is hampered by its high cost, the use of toxic NaBH4, and the production of harmful flammable hydrogen. Nowadays, researchers are more focused on the green synthesis of nZVI by environmentally friendly, low cost methods with simple operation. The green method refers to the use of polyphenols extracted from plants (such as green tea, oak, mulberry etc.) as the reducing substance of iron ions prior to forming nZVI. There have been numerous attempts to stable environmentally friendly nZVI on diverse supporting materials as clay, bentonite, and biomaterial in order to remove various pollutants. Clays are suitable for hosting nZVI and binding anions or cations of the contaminants through ion exchange or adsorption due to their large specific surface area and high cation exchange capacity (CEC). Furthermore, ions could be adsorbed at the clay crystal lattice's boundaries and interchange with other ions present in the water or sediment. Because of its porous structure, high adsorption capacity, and high specific surface area, biochar (BC) has been used as a supporter of nZVI for enhancing dispersibility in recent years. Immobilization in a support matrix, on the other hand, is used because as-prepared nZVI-based nanocomposites may preserve the benefits of both components and even display synergistic effects on pollutant removal. This work will review the possibility of using nZVIsynthetised with oak wood leaf and supported with native clay and biochar for the treatment of sediment contaminated with metals and PAHs and water contaminated with organic pollutants (Reactive Blue 4 as the model pollutant).

Key words: *environmental pollution, green synthetisednZVI, biochar, native clay*

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SYNTHESIS OF NOVEL ABA BLOCK POLYESTERS BASED ON RENEWABLE RESOURCES

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Abstract

Products of oil-based industry, especially polymeric materials, contribute to environmental pollution during production and after use. As a solution, the use of biodegradable materials is becoming more important. The industrial exploitation of products obtained from renewable raw materials is becoming a field of research that is attracting the attention of the scientific community. The advantage of these materials is the fact that after use, they can be completely degraded into harmless components. The substitution of petrochemical raw materials with materials from renewable sources also fits into the visions of ecological recovery of the planet. The goal of this work was the development of novel triblock ABA copolymers based on poly(lactide) as a hard segment and poly(methylricinoleate) as a soft, middle segment. First, poly(methylricinoleate) was synthesized by the method of high-temperature polycondensation in bulk, and then this dihydroxypolyol was used as a macroinitiator in the synthesis of triblock copolymers. The synthesis of triblock copolymer was carried out in a dichloromethane solution at a temperature of 36 °C using triflic acid as a catalyst. This was followed by ring-opening polymerization of L-lactide, initiated by -OH groups from the soft segment. Confirmation of successful synthesis of ABA blocks was done by ^{1}H NMR and FTIR spectroscopy. DSC analysis showed that by increasing the chain length of the L-lactide, the value of Tg of hard segments also increases and with a molar mass of hard segments of 10000 g/mol, PLLA chains were organized into crystalline domains, with a crystallization temperature of 73 °C. Based on the stress-strain curve for the obtained ABA blocks, it can be clearly seen that the soft segment, with its pendant chains, enables the production of elastomeric block copolyester.Compared to pure poly(L-lactide), the stress in the obtained block copolymers is lower, 65 MPa for pure PLLA and 40 and 36 MPa for blocks with a PLA content of 72 and 65wt%, respectively.As expected, the value of elongation at break increased significantly, from 6% for pure PLLA to 22% and 18% for blocks with PLLA content of 65 and 72%, respectively.

Key words: *block copolymers, biodegradable polyesters, poly(lactide).*

DEVELOPMENT OF NOVEL POLYURETHANE COATINGS BASED ON POLYOLS OBTAINED BY RECYCLING PET

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Abstract

Polyurethane (PU) coatings are characterized by excellent properties of anti-corrosion, adhesion, and chemical resistance, which is why they have found application in many areas, such as the furniture, transport, and automobile industries. Polyols used in the synthesis of polyurethane are largely petroleum-based and come from non-renewable sources. That is why there was a need to replace such components with polyols that are cheap and environmentally friendly. In this work, we synthesized polyurethane coatings using a commercial polyol and a polyol obtained by recycling polyethylene terephthalate (PET). Degradation of PET to polyols was carried out by the process of glycolysis. Two types of diisocyanates were used for the synthesis: aliphatic hexamethylene diisocyanate (HMDI) and aromatic toluene diisocyanate (TDI), to examine the influence of the starting components on the final properties of the coating. Castor oil was used as a plasticizer in amounts of 10, 20, 30, 40, and 50%. In order to examine the influence of polyols, structurally different diisocyanates, and the amount of plasticizer on the thermal properties of the coating, differential scanning calorimetry (DSC) was performed. Methods for testing dry coatings were performed on the synthesized PU coatings: thickness, hardness, chemical resistance, degree of adhesion, and impact resistance. The production of polyol by PET recycling was confirmed by Fourier transform infrared spectroscopy (FTIR), and the appearance of characteristic peaks for the urethane bond on the FTIR spectra confirmed the successful synthesis of the PU coatings. The results showed that polyurethane coatings with the necessary characteristics for their use are also obtained by using polyol obtained from PET recycling, as well as by using a commercial polyol, providing a new application for plastic waste and a replacement for petrochemical materials for PU synthesis.

Key words: *polyurethanes, coating, recycling of PET, plastic waste*

SYNTHESIS OF POLYURETHANE HYDROGELS

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Abstract

Because of their similarity to natural soft tissues, hydrogels are ideal for use in regenerative medicine. So far, already known hydrogel based on celluloses, alginates, PLAs, acryls of amides have been used.However, polyurethanes that are known for their solid structure have become more and more recentlyattractive, and they can also imitate soft tissues. Polyurethanes (PU), hydrophilic or insoluble in water, can be obtained by incorporating hydrophilic soft segments, e.g., poly(ethylene oxide) (PEO) in their structure. In this paper, new PU hydrogels were prepared by the polymerization process using aliphatic diisocyanate, high molecular weight diol and crosslinking agent. Synthesis was done in different environments, in room conditions, at elevated temperature and in vacuum. The goal was to obtain a hydrogel with a uniform structure, which is not porous. In synthesis, 2.7 functional isocyanates, polyethylene oxide with molecular weight of 2000, 6000 and 10000 g/mol, with the appropriate initiator, were polymerized in tetrahydrofuran as a solvent. The stirring was carried out at low speeds to avoid the formation of air bubbles. After the synthesis, the samples were dried and then subjected to characterization on infrared spectroscopy with Fourier transformation, Raman spectroscopy, Differential scanning calorimetry, Thermogravimetric analysis and a swelling ratio.

Key words: *polyurethanes, hydrogels, swelling properties*

MATERIAL TRANSFER FROM NATURE TO TECHNOLOGY

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Abstract

Biopolymers have a wide use in bioengineering due to their antimicrobial, antioxidant, biocampatible and non-toxic properties. In this seminar, production of three dimensional biomaterials from different organisms together with their characterization and application areas will be presented. The biomaterials that will be mentioned in this presentation will be a summary of our previous work. And these biomaterials are chitin, chitosan, cellulose and biosilica. The application areas of the produced 3D materials are i) drug loading and releasing properties, ii) food coating to increase the shelf life, iii) bio-cup production for healthy weight loss, iv) biological mesh samples to be used in surgical operations, v) production of multifunctional porous bioactive micro silica beads from a sponge for biomedical applications. In a general summary, the studies carried out by BIPEMAS research group in recent years and the projects that are planned for future will be mentioned. Nature has been producing fascinating materials since millions of years currently under explored. My primary research goals are i) to discover these secret materials in the nature (from plant or animal bodies), ii) to characterize them in detail by the state of the art techniques, iii) to solve how these materials naturally assemble in nano scale, iv) to establish inter disciplinary collaborations to explore the uses of these materials in various applications and v) to transfer them in to the industry for the benefit of the society.

Key words: *chitin, chitosan, cellulose, biosilica, drug delivery*

UTILIZATION OF RED MUD IN CEMENT AND CERAMIC MATERIALS PRODUCTION

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Abstract

Red mud is a solid waste residue from alumina production process of digesting bauxite ores with caustic soda. Due to serious environmental issues caused by landfilling, red mud (RM) recycling has gained popularity in recent years. Over the past few decades, numerous researchers have put in a lot of effort to create a variety of cost-effective red mud utilization techniques. Utilization of red mud in cement and ceramic materials production is also an effective way for recycling red mud on a large scale. The idea of our research was valorization of red mud from local alumina plants (Podgorica, Montenegro, and Zvornik, Bosnia and Herzegovina) as a raw material for production of cement and ceramic material. The following methods of material characterization were used: thermal, chemical and mineralogical characterization, morphological characteristics and particle size distribution. Based on the obtained results, laboratory production of cement and ceramic materials was carried out, and the final products were further tested. The obtained results showed that red mud can be used as a substitute for conventional raw materials in order to produce cements and ceramic materials with good properties. The presented research could have positive impact onconstruction sector which is moving toward decarbonization strategy, focusing on sustainability and minimization of negative effects on the environment and biodiversity.

Key words: *red mud, waste material, cement and ceramic materials production*

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THE BENEFICIAL USE OF SYNTHESIZED IRON NANOPARTICLES FROM CITRUS PEEL EXTRACTS FOR RIVER SEDIMENT STABILIZATION

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Abstract

Fruit peels were discarded as unavoidable wastes in the production of fruit juice, wasting resources and contributing to pollution issues. As a result of that, the resource utilization of Citrus maxima (pomelo) and orange peels are required. In the recent years, only traditional synthesis method have been known for production of iron nanoparticles. But, in this study iron nanoparticles were synthesized using citrus peel extracts to reduce Fe(III) in aqueous solution. Total phenol content, antioxidant capacity and pH value were applied to characterize the extracts of citrus peels. SEM, EDS, and FTIR methods were used to characterize the nanoparticles. Based on the characterization results, spherical iron nanoparticles with diameters ranging under 100 nm were successfully synthesized, without the presence of agglomeration. Furthermore, the nanoparticles were primarily made up of Fe0 nanoparticles that had been coated with various biomolecules derived from the extracts as capping or stabilizing agents. The paper presents also the problems of Begej sediment polluted with toxic metals and the method of treatment with the stabilization process using iron nanoparticles, synthesized from the extract of fresh orange and pomelo peels (FO-nZVI ; PO-nZVI), dried orange peel (DO-nZVI), as well as metal leaching tests used to evaluate treatment success. Dynamic test DIN 3841-4 S4, Toxicity Characteristic Leaching Procedure-TCLP and sequential extraction were used to show the advantages and limitations of different tests as means of predicting the behavior of contaminants. The toxicity test was also applied to determine the inhibitory effect of Vibrio fischeri bacteria from the sediment samples. Based on the results, the mixtures of sediment and citrus peel extracts-nZVI proved to be a non-hazardous waste, they gave the obtained values that were below the prescribed limit values. Green synthesis methods of Fe NPs using Citrus maxima (pomelo) and orange peel extracts were realizable as recycling peels wastes and were creating economic benefits for the application on river sediments.

Key words: *sediment, iron nanoparticles, stabilization, metals, citrus peel extract.*

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SWELLING BEHAVIOR OF Ag/PVA HYDROGEL NANOCOMPOSITES: INFLUENCE OF TEMPERATURE AND SWELLING MEDIUM

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Abstract

In recent years, nanocomposite materials based on polymer hydrogels with embedded metal nanoparticles have attracted tremendous attention due to their unique properties, and extremely wide range of applications. A three-dimensional network gives the polymer hydrogels ability to swell and expand, but not to dissolve. Due to their swellability in water, hydrophilicity, biocompatibility, and lack of toxicity, hydrogels are utilized in a wide range of biological, medical, pharmaceutical, and environmental applications.Silver nanoparticles (AgNPs) have been proven to be an effective antimicrobial agent and enhanced antibacterial properties have been demonstrated both in vitro and in vivo. Research efforts are directed toward exploiting the in situ synthesis of AgNPs within polymeric network architectures. Among different synthesis routes, gamma irradiation induced synthesis has been recognized as a highly suitable tool for the production of hydrogel nanocomposites due to the formation and sterilization of material in one technological step, which is so important in biomedical and pharmaceutical applications.In this work the swelling behavior of silver/poly(vinyl alcohol) (Ag/PVA) hydrogel nanocomposites in a different swelling medium (water and Simulated Body Fluid) at two temperatures (25℃ and 37℃) was investigated. The Ag/PVA hydrogel nanocomposites were prepared by radiolytic in situ synthesis of AgNPs in a previously crosslinked PVA network. The optical and structural analysis confirmed the presence of AgNPs with a diameter of around 10 nm and a face centered cubic crystal structure. These AgNPs are stable for a long period of time due to the interaction of the surface of the nanoparticles with the OH groups of PVA. The results of the swelling process indicate that increasing of AgNPs concentration in PVA hydrogel leads to an increase in swelling capacity and diffusion coefficient in comparison with PVA hydrogel.Moreover, the same effect on the swelling parameters is observed with an increasing of temperature from 25℃ to 37℃. On the other hand, swelling capacity in SBF decreases, in comparison with water, because it contains various ions that change the swelling process.Both hydrogel systems, PVA as well as Ag/PVA nanocomposites, show non-Fickian diffusion and Schott second order kinetics, at an early and extensive stage of swelling, respectively.

Key words: *Ag nanoparticles, PVA hydrogel, nanocomposites, gamma irradiation, swelling properties.*

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CORROSION RESISTANCE OF ALKYD SYSTEMS IN 5% NaCl

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Abstract

Corrosion protection by organic coatings is the most common way of protection. Organic coatings protect as much as 75% of all metal surfaces, followed by wood, paper, leather, glass, plastics, ceramic materials and others. It is an irreplaceable way of protection for some surfaces. Although there are different types of the organic coatings, alkyd coatings are the most widely used due to their satisfactory quality, ease usage and relatively low price. To protect the steel samples, the base paint for the metal: oxide red 3701 and enamel lacquer: blue 6611 (finish layer) were used. The colors were applied as following combinations (systems): sample 1 (1x base paint), sample 2 (1x basepaint and 1x finish paint), sample 3 (1x basepaint and 2x finishpaint), sample 4 (2x basepaint and 1x finishpaint), sample 5 (2x base paint and 2x finishpaint). The surfaces of the samples were examined by Leica EZ4 HD optical microscope before and after 21 days of exposure to a corrosive environment (5% NaCl). The corrosion resistance of alkyd systems in 5% NaCl depends on the thickness of the applied protection system, i.e. on combinations of base and finishing colors (enamel varnish). With an increase in applied layers, i.e. an increase in the thickness of the coating, the compactness of the coatings and their corrosion resistance increase. Corrosion currents calculated on the basis of potentiodynamic polarization method and electrochemical impedance spectroscopy (EIS) show that sample 5 had the best anticorrosion performancein 5% NaCl (steel protected by a system of 2x base paint and 2x finish paint).

Key words: *steel, alkyd coatings, electrochemical impedance spectroscopy, potentiodynamic polarization method, corrosion resistance, corrosion current.*

STUDY ABOUT MULTIPOINT PROJECTION WELDING OF ALUMINIZED STEEL PLATES

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Abstract

Projection welding is a joining process based on the electrical resistance of metal components that have small protrusions on the areas where assembly is desired. In this case, the welding electrodes that ensure the transfer of the electric current have a flat geometry, which allows uniform pressing of the areas with protrusions, which have the role of ensuring the concentration of the current lines for the formation of welding points. Excessive deformation can cause the protrusions to collapse rapidly, causing greater dispersion of the current and limiting the effect of localized heating and melting, and welding no longer occurs. The process is widely used in the electrical, electronic, automotive, food and construction industries, etc. The paper analyzes the effect of regime parameter values during the resistance welding process on the joints made between 2 steel components with surfaces protected by aluminization. The surface of one of the components was imprinted with 5 equidistant protrusions created by plastic deformation to concentrate the electric current lines and achieve melting points with a limited surface area. The thin layer of aluminum deposited on the surfaces of the parts has the role of protection against corrosion, but it produces hard compounds located on the welding interface. The chemical micro-composition analyzes performed with the EDAX method highlighted the diffusion effects of chemical elements in the welding area and the formation of hard compounds Al-rich loccated on the fusion line of the welded points. The microstructure of the welded areas was analyzed and the fracture strength tests of some welded samples were performed to establish the most suitable values of the welding process for this application. The parameters of the welding regime that were analyzed were: electrode pressure (2.8 - 5 bar), welding time (5-7 sec), welding power (17.7 - 20.5 kVA). The microhardness has been measured on base material, fusion line and heat affected zone (HAZ). Very high hardness values were measured above the welded point (about 850 HV0.2), due to the formation of hard Al-Fe compounds.

Key words: *projection welding, current, microstructure, tensile test, microhardness.*

INFLUENCE OF CURRENT DENSITY ON THE MORPHOLOGY OF HARD CHROME COATINGS

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Abstract

The influence of current density on the cathodic utilization of current, thickness and roughness of electrochemical chrome coatings, as well as the influence of current density on the hardness and adhesion of electrochemical chrome coatings, was tested. Electrochemical deposition of chrome coatings was carried out in industrial and laboratory conditions, and the obtained results have been compared. The chrome was deposited on the steel cathodesof known compositionusing the electrolytic deposition method. The composition of the cathodes was tested by the XRF method, using X-MET 8000 device. Electrochemical deposition of the coatings was done from three different baths. The first bath was an industrial bath in „ORAO" a.d. company, containing the electrolytes of composition used for industrial needs, while the electrochemical chrome coatings from the other two baths were obtained in laboratory conditions, wherea laboratory beaker was used as an electrochemical reactor. The concentration of electrolytes in the first and the second bath is the same (250 g/dm^3 CrO_3; 2,5 g/dm^3 H_2SO_4), while the concentration of the electrolyte in the third bath is twice higher (500 g/dm^3 CrO_3; 5 g/dm^3 H_2SO_4). The electrochemical chrome coatings were deposited for 30 minutes, at the current density 35, 40, 45, 50and 55 A/dm^2, and at the bath temperature 60^{0}C. The roughness of the coatings was determined with the „Mitutoyo"measuring device, the thickness with the „PosiTector"coating thickness gauge, Vickers hardness test was performed to measure the hardness, while the adhesion was determined by using a bend test. It was observed that the cathodic utilization of current increases with the increase of the sulphuric acid content in the electrolyte, and the thicker chrome coating is formed. That shows that sulphuric acid has an electrocatalytic effecton the deposition of chrome coatings. The least utilization of current is in industrial conditions due to the great losses.

Key words: *chrome coatings, electrochemical deposition, electrocatalysis, current density, roughness, utilization of current, hardness, adhesion, coating thickness.*

ENHANCING THE CORROSION RESISTANCE OF β-TYPE Ti-Nb-Ta-Zr ALLOYS THROUGH CrN PVD COATING: AN IN-VITRO ELECTROCHEMICAL EVALUATION

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Abstract

Metallic alloys are classified into 316L, CoCrM alloy, and Ti alloys. Stainless steel Co-Cr-Mo has a low corrosion resistance compared to Ti alloys. Due to their high corrosion resistance and passivity films, Ti alloys are more suitable for medical applications. Titanium alloys are divided into three groups according to the type and amount of alloying elements. Those groups are α, α+β, and β-type alloys. Compared to α+β or α alloys properties, β alloys has remarkable elasticity, higher hardenability, and corrosion resistance and are more economical. Besides, most significate advantage of β-type titanium alloys is that their elastic modulus is considered the closest to the bone.β-type TiNbTaZr (TNTZ) alloys are suitable materials with these properties, but their use in facial and maxillofacial surgery applications where hardness is at the forefront besides biocompatibility is quite limited. The best way to avoid this problem is to cover the implant surface with hard coatings. By the way, many surface coating techniques are used for this purpose. These methods include the PVD technique; It is a widely used thin- film coating technique due to its relatively low production cost, high corrosion and wear resistances, and good adhesion resistance between the coating layer and the substrate. Thus, the TNTZ alloys, which do not contain toxic and allergic elements, have been coated with hard CrN PVD coatings to increase their in-vitro corrosion resistance in this study. In-vitro electrochemical behavior of the CrN coating and uncoated TNTZ alloy was evaluated by using open circuit potential (OCP) and potentiodynamic polarization (PDS) techniques, respectively. The characterizations of the coatings were carried out using scanning electron microscopy (SEM), energy dispersion spectroscopy (EDS), and X-ray diffraction (XRD). The SEM examinations showed that the CrN coating is homogeneous. Besides, CrN coating had a higher corrosion resistance than uncoated TNTZ alloy in Hank's solution.

Key words: *Biomaterial, PVD, coating, in-vitro corrosion, CrN, TiNbTaZr alloy*

CORROSION RESISTANCE OF BINARY (Ge–Sn, Ge-In, In-Sn) AND TERNARY (Ge-In-Sn) ALLOYS IN 3% NaCl

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Abstract

The importance of the alloys examined for the purpose of this study can be attributed to the specific properties of the Ge, Sn and In elements themselves. This paper investigates corrosion resistance of binary alloys $Ge_{50}Sn_{50}$, $Ge_{50}In_{50}$, $In_{50}Sn_{50}$ and ternary alloys $Ge_{20}In_{40}Sn_4$, $Ge_{40}In_{30}Sn_{30}$, $Ge_{40}In_{20}Sn_{40}$, $Ge_{17,5}In_{65}Sn_{17,5}$, $Ge_{35}In_{35}Sn_{30}$, $Ge_{15}In_{15}Sn_{70}$, $Ge_{10}In_{10}Sn_{80}$ in test solution. The mass of the tested samples was about 7g and the dimensions were (15x15x1) mm. The corrosion resistance of these alloys was examined in 3% NaCl solution using the potentiodynamic polarization method (Tafel plots) and electrochemical impedance spectroscopy (EIS). Tafel plots were fitted using the DC Corrosion Technique software. The results of electrochemical impedance spectroscopy (EIS) were fitted using the GamryEchem Analyst program and the corresponding equivalent circuit. The value of the exponent n was used to determine the way the electrochemical corrosion process unfolds in the tested systems. The corrosion resistance of binary alloys decreases in the following order: $Ge_{50}In_{50}$, $Ge_{50}Sn_{50}$, $In_{50}Sn_{50}$. The corrosion resistance of ternary alloys decreases in the following order $Ge_{10}In_{10}Sn_{80}$, $Ge_{15}In_{15}Sn_{70}$, $Ge_{40}In_{30}Sn_{30}$, $Ge_{40}In_{20}Sn_{40}$, $Ge_{20}In_{40}Sn_{40}$, $Ge_{17.5}In_{65}Sn_{17.5}$, $Ge_{35}In_{35}Sn_{30}$. The obtained results of corrosion resistance are compatible and have fundamental and practical significance. They enable a better understanding of the possibilities of practical application of the tested alloys.

Key words: *binaryalloys, corrosion resistance, electrochemical impedance spectroscopy, potentiodynamic polarization, ternary alloys*

BIMETALLIC KNIVES FOR BRANCH CHOPPERS

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Abstract

The paper presents the concept of bimetallic knives made on the principles of repetitive preventive maintenance, which are part of the mechanical systems of the branch shredders used in ecological farms.Currently, the blades of the branch choppers have widths of up to 70mm, being manufactured in two versions: monobloc, from heat-treated high-alloy steels or from bimetals, obtained by co-rolling of two steels having different properties and chemical composition. In the bi-metal type solution, one of the materials has the role of ensuring the sharpness of the cutting edge of the knife and the second gives the necessary thickness to withstand the working mechanical stress. The solution proposed and carried out by the authors of the work is that of using a bimetal manufactured from a low alloyed manganese steel, on which a layer with self-sharpening properties is deposited by welding, using the manual metal arc welding process and as filler materials coated electrodes. For this purpose, the knife substrate was cut to the dimensions of monobloc type knives but corrected with shrinkage and resharpening allowances. The substrate was preheated before hard facing to 150°C, then weld deposition was cladded on the active edges. The deposition is a Fe-2%W-Cr alloying system that provides a hardness around 60 HRC, associated with good abrasion resistance in high pressure conditions. For easy post-processing, weld hard deposition is performed using two wear plates on each side of the blade, which are thick enough to ensure rapid cooling. The hard deposit can be rebuilt, under safe operating conditions, up to three times, otherwise microcracks may appear starting from the weld deposit and growing towards the substrate. The welding loading sequence is established so that the residual manufacturing stresses are in balance, as far as possible, with the operating stresses, these being located especially in the central area of the knife. The value of the heat input during welding is set so that the welded deposits have fine-grained martensitic structures with small acicular carbides, which have good behavior in the process of cutting tree or shrub branches. The application of the innovative method of manufacturing knives for branch choppers ensures farmers longer periods of good operation, the reduction of the costs necessary to purchase new knives from equipment suppliers and increased efficiency in valorizing wood waste results from agricultural activities.

Key words: *bimetallic knives, welding, hardfacing, hardness*

EXPERIMENTAL DETERMINATION AND NUMERICAL VALIDATION OF THE CRITICAL VALUE OF THE J-INTEGRAL OFA LOW CARBON MICROALLOYED STEEL FOR ELEVATED TEMPERATURE APPLICATION

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Abstract

To evaluate the behavior of a homogeneous material in the presence of a crack-type defect, the value of the critical stress-intensity factor, K_{Ic}, *was determined as a measure of the fracture toughness of the tested steel under the conditions of a plane stress state, at two test temperatures, 20℃ and 540℃. The experiments were carried out using the method of testing one specimen with successive partial unloading, which aims to register the size of the crack development, Δa, that occurs during the test. In addition to the experimental analysis, a numerical simulation of the behavior of the specimens under static and dynamic loading was performed. The numerical analysis is based on the experimentally obtained yield strength and tensile strength values of the investigated steel, and was done in Ansys Workbench R21 software package, which relies on finite element method, FEM. The results obtained by numerical analysis showed good agreement with the experimentally obtained results of the J-integral for specimens tested at room and elevated temperature. Good agreement with the experimental results was shown, confirming the use of FEM for the load cases considered.*

Keywords*: Steam pipline, J-integral, CT-specimen, Finite Element Method.*

RADIOLOGICAL CHARACTERISATION OF RED MUD AS POTENTIAL CONSTRUCTION MATERIAL

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Abstract

Red mud remains as residue from the processing of bauxite using different methods. It also contains dozens of other elements, including naturally occurring radioactive elements such as uranium and thorium. Red mud is most often deposited in special locations in the form of a highly alkaline suspension. The amount of emitted red mud is increasing every day, and its disposal is a potential environmental hazard. Tested samples were collected at the red mud lake of the company Alumina Ltd. Zvornik. The concentration activity of natural radionuclides was determined using a high-purity germanium detector (HPGe). The concentrations of ^{208}Tl, ^{210}Pb, ^{212}Bi, ^{212}Pb, ^{214}Bi,^{214}Pb,^{234}Th were determined by gamma spectrometric methods. The aim of this work is to determine the concentration of activity of natural radionuclides in red mud and consider its use through environmentally safe methods.

Key words: *red mud, natural radionuclides, HPGe*

DEVELOPMENT OF PEROVSKITE BIOPOLYMERIC FILM WITH PHOTOLUMINESCENT PROPERTIES

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Abstract

Energy-efficient materials, such as perovskites, have attracted attention due to their characteristics, low costs, and variety of production methods, allowing them to be used in optoelectronic devices. However, they become unstable when exposed to air, humidity, or temperatures, so structures with sustainable materials are explored to maintain their durability, optimize their fabrication, and costs. Hence, it is proposed to synthesize perovskites $CsPbBr_3$ in a biopolymeric matrix, which promotes the use of hydrocarbon-free polymers.The implemented polysaccharides are from potato and invasive aquatic plants of Lake Tota (Elodea), and were dissolved with the precursors (lead acetate and cesium bromide) in dimethyl sulfoxide and dimethylformamide under ambient conditions. Finally, different techniques were used to study the optical, morphological, and structural properties of the material, confirming its application feasibility by obtaining homogeneous, photoluminescent films and a process where the starches behaved as organic ligands for the formation of perovskite.

Key words: *perovskites, biopolymer, starch, aquatic-plants, organic-ligands, photoluminescence*

INVESTIGATION OF CORROSION BEHAVIOR BY ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY OF Al ALLOYS IN Al-Mg SYSTEMS

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Abstract

From the aspect of corrosion stability, aluminum alloys can be divided into corrosion stable and corrosion unstable alloys. However, it should be emphasized that the corrosion properties themselves are not the only relevant factor for their use, because the use is also influenced by mechanical characteristics. In general, these properties are greatly influenced by the chemical composition, which affects the structure, and the main factor that influences the corrosion stability is presence and concentration of alloying elements. The aim of this work was to show the corrosion characteristics of alloys of the Al-Mg system, which is a continuation of previous work of the authors that was conducted in this area. Corrosion characteristics of aluminum were examined using electrochemical impedance spectroscopy during exposure in an aqueous solution of 3 wt. % NaCl. The obtained data were analyzed by equivalent electrical circuits of different configurations with a special discussion related to the appearance and type of oxide layer that is formed due to the effect of the corrosive environment on the sample and the behavior of the samples in the corrosive environment. Equivalent circuits describe the impedance responses well, and the values of the circuit parameters correspond to the proposed model of physical-chemical changes during the corrosion process of the investigated systems. EIS data indicated considerably greater corrosion resistance aluminum with higher Mg content. The corrosion processes on Al alloys with higher Mg content are subjected to more pronounced diffusion limitations in comparison to the processes below the passive oxide film, as a consequence of the formation of a highly compact protective coating. The results show that the addition of Mg is an effective way to improve corrosion resistance for aluminum.

Key words: *aluminum alloys; corrosion behavior; chemical composition; mechanical properties; electrochemical impedance spectroscopy; equivalent circuit.*

MIGRATION OF CARVACROL AND THYMOL FROM BIOPOLYMER ACTIVE FILMS INTO DIFFERENT MODEL SOLUTIONS

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Abstract

Biopolymer packaging materials possess many positive properties, and one of the most investigated is their possibility to act as a matrix of active compounds. Essential oils belong to a group of natural compounds consisting primarily of phenolic components, which are responsible for their strong antioxidant and antimicrobial activity. Incorporating essential oils into biopolymer packaging materials is an increasingly common alternative to replace synthetic additives. However, sensitivity, volatility of phenolic components, as well as strong sensory impact limit their use as additives. A new approach in food preservation industry involves the use of different encapsulation agents in order to form micro and nanoparticles, which are intended to protect the active component and allow their gradual and slow release in food product. In this work, the migration of carvacrol and thymol from 5 different biopolymer active materials based on pumpkin oil cake (PuOC), zein, chitosan, starch and gelatin, with 1% of Satureja montana essential oil or 1% inclusion complex β-cyclodextrin/essential oil S. montana (β-CD/EO), was determined. The test was performed in four different model solutions, food simulators: 96% ethanol solution, simulator of fatty foods; 10% ethanol solution, simulator of alcoholic foods; distilled water, simulator of natural foods; 3% acetic acid, simulator of acidic foods. In addition to the active biopolymer films, the migration of carvacrol and thymol from the inclusion complex β-CD/EO into all 4 model solutions was also determined. The migration results of carvacrol showed that its highest content was in model ethanol solutions (96% and 10%), given its hydrophobic nature and better solubility in organic solvents. Films with pure essential oil had a higher content of carvacrol compared to films with the addition of an inclusion complex. These results may indicate that carvacrol content was not completely released from the inclusion complex into the solution model, due to the protection of the phenolic components of the essential oil by encapsulation in the inclusion complex, and strong bonds between the inclusion complex and biopolymer films. After incorporation of the inclusion complex into various biopolymer protein, polysaccharide and composite films, the migration of carvacrol was made even more difficult. The results of thymol migration showed that the content of released thymol in all four food simulants, for all biopolymer films, was significantly lower compared to the obtained values of carvacrol, given its lower relative share in the S. montana essential oil.

Key words*: biopolymer films, β-cyclodextrin, Satureja montana essential oil, carvacrol, thymol.*

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APPLICATIONS OF SILICA GELS

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Abstract

Silica gel is a widely used material in chromatography due to its unique porosity and adsorption properties. It is a porous, amorphous form of silicon dioxide with a high surface area and chemical active silanol groups, making it an ideal support material for the stationary phase in reversed-phase and normal-phase chromatography. The main advantage of silica in contrast to resins is its mechanical and chemical stability. It withstands temperatures up to 300°C and is pressure-stable up to 600 bars. Silica manufacturers can design surface area and pore size making it ideal for various purification challenges of nutraceuticals, APIs, peptides, and nucleotides or scavenging of metal ions from wastewater.
One successful application of silica is Supercritical Fluid Chromatography (SFC) of fish-oil to purify omega-3- fatty acids to pharma grade purity. SFC offers an organics- & solvent-free and environmentally friendly solution, while it is faster, more economical and has a high recovery rate. Silica is the perfect base material for SFC due to its polar surface and high mechanical stability. We investigate how the optimization of chromatographic conditions and of the silica surface can improve the selectivity by over 25%. Silica surface functionalized with hydrolysed 3-Glycidoxypropyl-ligands (DIOL) gives a certain hydrophobicity while still providing hydroxy groups that can interact with the target molecule.
Conventional reversed phase chromatography can be used to separate single cannabinoids such as CBD, THC, CBG, CBC or THCA. Literature shows plenty of examples that successfully separate the cannabinoids and its corresponding acids. They usually use methanol and addition of acids, small particle sizes (< 5µm) of the stationary phase and expensive, but highly selective phases. These conditions are not suitable for scale-up. The design and scale-up of a preparative process that purifies CBD and THC requires more insights into chromatographic principles and optimization. A well designed preparative chromatographic purification can achieve > 98% purity CBD with a yield of > 80% and even the separation of single THC isomers (Δ^9-THC).

Key words: *Chromatography, SFC, Omega-3 fatty acids, cannabinoids, purification*

SILICA GELS SYNTHESIS

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Abstract

Silica gel is porous, amorphous form of silicon dioxide with a high surface area and controlled pore size, making it an ideal support material for variety of applications, including catalyst support, stationary phase in chromatography and separation membranes, but also in biomedical applications such as drug delivery, tissue engineering and biosensors due to its biocompatibility.
Porous silica gel is synthesized by sol-gel chemistry. Sol–gel chemistry is the preparation of inorganic polymers or ceramics from solution through a transformation from liquid precursors to a sol and finally to a network structure called gel. Sol-gel process begins with the hydrolysis of precursor compound (silica source) in a solvent, typically alcohol or water. The hydrolysis reaction creates silanols, which then undergo condensation reactions to form siloxane bonds and produce a gel-like material. The resulting silica gel can be dried and calcined to remove the solvent and any organic additives and create a highly porous, high surface area material.
There are numerous parameters in sol-gel process with important influence one textural and structural properties of final silica gel product. The process is strongly affected by initial reaction conditions: nature of precursors, the molar ratios between the reactants, the nature of the solvent, use of modifying agents, pH and the synthesis temperature. Furthermore, preserving the microstructure and thus the properties of the resulting material in downstream processing steps such aging and drying in the industrial settings can be a challenge. Advantages and as well disadvantages of sol-gel process for silica synthesis are summarized.

Key words: *Silica gel, Sol-gel, Process parameters, Scale up*

TECHNOLOGIES OF MAKING SMART HOUSES

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Abstract

The term "smart house" means a residential structure in which several automation elements are integrated into a single system, enabling the management of various electrical devices. Automation systems in smart houses can manage: devices for heating, cooling, ventilation and air conditioning, electric lighting, blinds, awnings and curtains, ramp, gate and garage door, kitchen appliances, multimedia, watering systems, security systems, pool water level and temperature, video surveillance, scenes, etc. Smart houses contribute to: making the life of their users easier, maintaining comfort conditions at the desired level, greater energy efficiency, increasing the safety of people and material goods, because they use safety systems, such as: anti-burglary systems, fire protection systems, water leak detection systems, gas detection systems, video surveillance systems, etc. Smart housescontribute to environmental protection. The use of real smart homes improves energy efficiency as they reduce energy consumption. If the energy comes from fossil fuels, which emit smoke, soot, ash and other harmful substances into the atmosphere during combustion, smart houses contribute to the protection of the environment and climate change mitigation. There are several technologies that can be used to implement automation systems in smart homes: automation systems can be installed in already built houses with traditional power installations, or they can be planned during the design phase of new smart homes and carried out during their construction. Automation systems in smart homes can be with centralized or cecentralized control. Automation systems in smart homes are installed using appropriate equipment and software, such as: sensors, actuators and microcontrollers, control devices (smart phones, remote controls, etc.), and communication networks. Sensors, actuators and microcontrollers which control the physical parameters of the environment (temperature, light, humidity, etc.). Control devices are used to control electrical devices in the building by sending data or signals to actuators to activate or deactivatethem.Automation systems in smart homes are designed so that electrical devices can be turned on and off using: Smartphone or tablet, remote control, and sensors (temperature, light, humidity, movement, smoke, etc.). Communication networks are used for data transfer between automation elements. They canbewired andwireless. In wired networks, signal transmission from control devices to actuators is carried out via a bus, which is made of special conductors or twisted pairs. The advantage of wired networks is reliability due to the use of shielded conductors, which eliminates interference. The networks provide high data transfer rates. In wireless networks, radio signals are transmitted from the main device (control panel) to the actuator, which reduces the number of wires that need to be installed in the walls of the building, as well as the time required to install the device. The operation of the system depends on the quality of the radio signal. Protocols are actually a "language" with which automation elements in a smart home communicate. Automation system protocols can be open protocols and closed protocols. Wireless network protocolsinclude:ZigBee, Z-Wave, Bluetooth, Wi-Fi, Thread, Buspro, etc. Wired network protocolsinclude: X10 and KNX.

Key words: *smart house, smartphone, communication networks, automation systems.*

FOOD REGULATIONS

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Abstract

The main objective of this paper is to present the legislation on food that is in force in the European Union and Bosnia and Herzegovina, on the basis of which the degree of harmonization of food regulations in BiH with the current legislation in the EU can be seen. The progress of human civilization, the increase in production, as well as the appearance of various illnesses and diseases led to the need to find new laws and standards that will regulate the area of food production and distribution, which is discussed in the introductory chapter of this paper. The second chapter of this paper describes international regulatory agencies whose main task is the protection of human and animal health, and whose emergence is a consequence of globalization in the field of food trade, which obliges exporting and importing countries to tighten and implement food control measures. In the third chapter of this paper, the reasons and way of creation of the EU are described. The EU is the main importer of food and animal feed. Strict import rules on food and feed hygiene, consumer safety and animal health status aim to ensure that all imports meet the same high standards as products from the EU itself. Import controls are crucial for checking compliance of food and animal products with EU requirements. In the fourth chapter of this paper, the Regulation of the European Parliament and the Council is described, which established the rules for the performance of official controls and other official activities by EU member states. In the fifth chapter of this paper, the Regulation on informing consumers about food, which is currently in force, is described, as well as the way of developing the EU legislation on food declaration. The EU food legislation represents one of the most complex packages of legal regulations in the Union, but also in the whole world. EU food legislation is described in the sixth chapter of this paper. Accession to the EU is a strategic priority of BiH, which is based on a broad political consensus within BiH. The process of European integration requires a comprehensive adjustment of policies, institutional framework and legal system with the aim of reaching European standards in all areas. The harmonization of regulations in the field of food legislation is one of the biggest challenges on BiH's European path to which more attention must be paid, in order to raise the safety of people and animals to the highest possible level.

Keywords: *food legislation, European Union, European integration, harmonization of food regulations*

REGIONAL TRENDS AND ASPECTS OF ELECTRICITY GENERATION FROM RENEWABLE SOURCES

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Abstract

Renewable energy sources are resources preserved in nature and are restored in whole or in part, and can be used without complete exhaustion. Therefore, sustainable energy or green energy is an energy efficient way of producing and using energy that has as little adverse impact on the environment as possible. Renewable energy sources (hydropower, wind energy, solar energy, geothermal and ocean energy, biomass and biofuels) are substitutes for fossil fuels and contribute to reducing greenhouse gas emissions, diversifying energy supply and reducing dependence on unreliable and unstable fossil fuel markets, especially oil and gas. In 2018, the European Union goal was set that the share of energy from renewable sources in energy consumption in the Union by 2030 would be 32%. In view of the EU's new climate ambitions, a revision of that goal was proposed to the co-legislators in July 2021 so that this share would be 40% by 2030. Following Eastern Europe instability during 2022 and the resulting wider energy crisis, the EU reached an agreement to rapidly reduce its dependence on fossil fuels (coal, oil, gas) by 2030 through an accelerated transition to green energy. An updated renewable energy policy framework for 2030 and beyond is currently under discussion. These developments and current as well as future EU policies certainly have an impact on the region. In this paper, the authors provide an overview of the general trends, current situation, as well as quantitative analysis of electricity generation from renewable sources in the region. Based on the above, appropriate observations, conclusions as well as recommendations regarding the trends and the current situation in the region were presented.

Keywords: *energy, electricity, renewable sources, system.*

HYPERAUTOMATION - NEW TREND IN INDUSTRY DEVELOPMENT

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Abstract

Hyperautomation is the next big and significant technological jump in the field of industrial automation. It implies the purposeful and simultaneous combining and "stacking" of innovative technological solutions and platforms for the optimization of a given activity or task. The key elements of this concept are robotic process automation, which is based on human behavior in the execution of various protocol and repeatable tasks, artificial intelligence - AI, machine learning, natural language processing, as well as platforms for intelligent data processing (IDP).Technologies for optical recognition and reading of characters are also applied. In practice, they perform electronic translation of handwritten or typed information into machine coded text. The source of information is usually a scanned document or a digital photograph of it. IDP technology is the base in the digitization process, as the first and most important stage in it, which automates the intensive conversion of data from physical (paper) media into electronic form. Hyperautomation has the flexibility to provide customizable solutions that meet the needs of a particular enterprise or industry, driving their digital transformation.It achieves a harmonious and intelligent finding of operational solutions (machines, robots, firmware, software, SCADA systems, human-machine interfaces and integrated computing technologies) with information (tools and hardware for data acquisition, storage and processing, networking, IoT and IIoT applications, etc.) in the production ecosystem. The growing popularity of the so-called "low/no-code" platforms for the development of software applications lies in the fact that these activities are available to practically every employee in an industrial enterprise, and not only to programmers with special qualifications.The result is a holistic process of human-machine interaction to achieve maximum autonomy. The main difference between automation and hyperautomation is that the first one seeks to improve the execution of individual tasks, e.g. by implementing a collaborative robot instead of a human at the workstation, while the other seeks to optimize the production process through a holistic approach. This is where the logical end goal of industrial automation is reached, i.e. fully autonomous production or production "with the lights off" - without the need for any operator intervention. It is convenient appropriate to make a semantic diferenceamong terms "automatic", "automated" and "autonomous".While the first two assume static, pre-programmed, strictly limited and one-dimensional human-driven activities, the latter excludes the need for human participation in them. Technologies such as IIoT, AI, machine learning and data analytics tools provide increasing added value in modern industry by independently adjusting and optimizing technological processes "on the fly" - in real time. With the help of peripheral platforms, the computing capacity needed for this purpose "leaves" the data centers and is located on the periphery of industrial networks (edge computing), close to real machines and equipment. In just one decade, the concept of production "in the dark" or "with the lights off" due to the eliminated need for human presence has turned from a futuristic idea into a real operational strategy, and the first truly fully autonomous factories are already a reality in the world.

Key words: *industrial automation, hyperautomation, autonomous production, robotics*

INDUSTRY 5.0 - DEVELOPMENT AND PERSPECTIVES

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Abstract

For industry to become a source of real prosperity, its real purpose must include social aspects and environmental considerations. This includes responsible innovative activity that aims not only to reduce costs or maximize revenue, but also to increase prosperity for all participants in the chain - investors, workers, consumers, society and the environment.The industry must be sustainable and develop circular processes that reuse and recycle natural resources and reduce waste generation and environmental impacts. Sustainability means reducing energy consumption and greenhouse gas emissions, preventing the depletion and degradation of natural resources to ensure that the needs of present generations are met without compromising the needs of future generations.Technologies such as artificial intelligence and additive manufacturing, which optimize resource efficiency and minimize waste, can play a big role here. A greater degree of stability is needed in industrial production, by providing better protection against disruptions while being able to deliver critical infrastructure at critical times. Geopolitical changes and crises such as the COVID-19 pandemic highlight the vulnerability of the current approach to globalized production.Industry 5.0 is based on technologies that represent a set of complex systems, while each of them individually can realize its potential only if it is combined with the others. The first category includes customized human-machine interaction solutions that aim to connect people with technology, help people, and combine human-developed innovations with machine capabilities.The new technologies help people with physical and cognitive tasks: recognizing multilingual speech and gestures and predicting human intent; technologies for monitoring the mental and physical workload and stress level of employees; collaborative robots that work together with people and support their activities; augmented, virtual or mixed reality technologies, especially for learning and inclusion; increasing human cognitive abilities - technologies for combining the powers of artificial intelligence and the human brain (for example, combining creativity with analytical skills), decision support systems.The second category includes technologies and smart materials inspired by biological organisms. These technologies and processes can be integrated with, for example, the following features: independent problem solving; simplified design; possibility of recycling; obtaining raw materials from waste; integration of living materials; integration of sensor technologies and biosensors and ergonomics.The third category includes digital duplicates and simulation technologies that can optimize production, test products or identify possible adverse effects, for example through digital duplicates of products and processes; virtual simulations and product and processtesting (for example for human orientation, safety at work); multidimensional dynamic modeling and simulation; simulation and measurement of environmental and social impacts; cyber-physical systems and digital counterparts of entire systems; regular maintenance.Digital technologies will play a special role. While digital interconnectivity will facilitate the deployment of a range of sustainable technologies (including data acquisition, automated risk analysis and automated restrictive measures), increased reliance on digital technologies puts the industry at risk of technical disruptions resulting from failures and cyber-attacks. Researchs and innovation will play a key role in providing the necessary level of cyber security for a sustainable industry of the future.

Key words: *Industry 5.0, artificial intelligence, collaborative robots, cyber security*

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