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BOOK OF ABSTRACTS

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FACULTY OF TECHNOLOGY ZVORNIK

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IX INTERNATIONAL CONGRESS

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EEM2025

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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.

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.

NON-TREATED AND UV-IRRADIATED *PAEONIA TENUIFOLIA* PETAL EXTRACT-LOADED LIPOSOMES

Natalija Čutović[1*], Petar Batinić[1], Tatjana Marković[1], Branko Bugarski[2], Aleksandra A. Jovanović[3]

[1]*Institute for Medicinal Plant Research, "Dr Josif Pančić", Tadeuša Košćuška 1, Belgrade, Serbia, ncutovic@mocbilja.rs**
[2]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*
[3]*University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia*

Abstract

Paeonia tenuifolia L. petals contain bioactive compounds, such as phenolic acids, flavonoid glycosides and aglycones, anthocyanins, anthocyanidins, terpene derivatives, etc. However, the application of the mentioned bioactives from this source is rather low due to the fact that a higher amount of petals need to be collected in order to obtain a decent amount of these compounds, thus leading to the need for large meadow areas covered only in steppe peony. In addition, Paeonia petal bioactive compounds are characterized by their low solubility, stability, integrity, permeability, and consequently bioavailability. Therefore, the encapsulation of these hard-to-obtain P. tenuifolia petal bioactive molecules into liposomal particles can be advantageous. In the present study, P. tenuifolia petal extract-loaded liposomes were prepared using thin film method and characterized in terms of encapsulation efficiency (EE), vesicle size, polydispersity index (PDI), zeta potential, mobility, and radical scavenging potential before and after UV irradiation. The EE was high and amounted to >75%, while UV irradiation did not influence the mentioned parameter, i.e., UV irradiation did not cause the leakage of encapsulated compounds. The vesicle size was significantly high and amounted to 4959.7 ± 131.2 nm for non-treated and 5030.0 ± 73.6 nm for UV-irradiated liposomes, while the liposomal dispersion system was homogeneous and PDI was 0.252 ± 0.065 and 0.222 ± 0.025, respectively; the differences were not statistically significant. The zeta potential and mobility for the non-treated sample were -10.93 ± 0.38 mV and -0.857 ± 0.028 μmcm/Vs, respectively indicating lower stability of the liposomal system. However, UV irradiation caused a significant change in both parameters and reversal from negative to positive values; namely, the zeta potential was +7.70 ± 0.15 mV, while mobility amounted to 0.604 ± 0.012 μmcm/Vs. In the ABTS antioxidant assay, extract-loaded liposomes neutralized 63.1 ± 1.4% of the ABTS radicals, whereas after UV irradiation antioxidant potential was significantly lower (55.0 ± 1.3%). On the other hand, UV irradiation did not influence DPPH radical scavenging of the liposomal particle and the IC_{50} value was ~10.7 mg/mL in both cases (non-treated and UV-irradiated samples). Future experiments should be focused on the reduction of vesicle size of the obtained liposomes using sonication and/or extrusion and improvement of zeta potential and consequently stability with the aim to implement P. tenuifolia petal extract-loaded liposomes in food, functional food, pharmaceutical, and cosmetic products.

Keywords: *steppe peony, encapsulation, biological activity, encapsulation efficiency.*

SATUREJA MONTANA EXTRACTS: THE IMPACT OF TEMPERATURE IN MICROWAVE-ASSISTED EXTRACTION

Natalija Čutović[1*], Tatjana Marković[1], Aleksandra Jovanović[2], Petar Batinić[1]

[1]*Institute for Medicinal Plant Research, "Dr Josif Pančić", Tadeuša Košćuška 1, Belgrade, Serbia, ncutovic@mocbilja.rs**
[2]*University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia*

Abstract

Aromatic plants of the Lamiaceae family are valuable food and medicinal sources due to their antioxidant, antimicrobial, antispasmodic, expectorant, carminative, antiulcer, stimulant, anticancer, anti-proliferative, and diuretic effects. Biologically active compounds obtained from plant resources have gained more attention nowadays, due to the consumerism demand for functional food and pharmaceuticals based on natural compounds. In the present study, Satureja montana herba was evaluated as a source of antioxidant polyphenol components, which were extracted by the application of a microwave assisted extraction device. Microwave-assisted extraction has become a good alternative extraction procedure in comparison to traditional techniques due to its high efficiency, faster kinetics, and reduced extraction medium consumption, which is in accordance with the aim of the manufacturing sector to seek out eco-innovative technologies, which minimize the loss of bioactive compounds. Optimization of the extraction was carried out by varying the extraction temperature (60-200°C) in 50% ethanol, at a 1:40 solid-to-solvent ratio for 150 s. The extraction efficiency was expressed in terms of total polyphenol content (TPC), total flavonoid content (TFC), and DPPH radical scavenging capacity (expressed as the IC_{50}, the concentration of the extract requires to neutralize 50% of free radicals). The highest TPC was recorded in the extract prepared at 160°C (1.77±0.14 mg gallic acid equivalent - GAE/g dry extract), while the highest TFC was in the extract obtained at 180°C (0.39±0.01 mg catechin equivalent - CE/g dry extract). Also, the level of polyphenol yield was correlated with free radical scavenging activity and the IC_{50} value was the lowest (the highest antioxidant activity, 5.30±0.21 mg/mL) in the sample with the highest TPC. This study revealed that polyphenol and flavonoid yields and antioxidant potential of S. montana extracts were significantly affected by the temperature in the microwave-assisted extraction. This is the first step in obtaining the highest amount of bioactive compounds from S. montana that can be used in the food, pharmaceutical, or cosmetic industry, in their free form or encapsulated into adequate carriers.

Keywords: *winter savory, bioactive compounds, extraction optimization.*

THE IMPACT OF VARIOUS TEMPERATURES ON POLYPHENOL AND FLAVONOID EXTRACTION FROM *Fumaria officinalis* HERBA

Rabiea Ashowen Ahmoda[1], Andrea Pirković[2], Milena Milošević[3], Aleksandar Marinković[1], Aleksandra Jovanović[2*]

[1] *University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*
[2] *University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia, ajovanovic@inep.co.rs**
[3] *University of Belgrade, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia*

Abstract

Polyphenols are a large group of plant secondary metabolites that can be employed as preservatives, antioxidants, and additives. Flavonoids, as an important group of polyphenols and natural antioxidants, may reduce oxidative stress in cardiovascular and neurodegenerative diseases, diabetes mellitus, asthma, and eye disorders. The objective of the present study was to investigate the influence of high temperature on the extraction of polyphenols and flavonoids from fumitory (Fumaria officinalis L.). The polyphenol yield varied in a range of 16.56 to 18.33 mg gallic acid equivalent/g of dried plant material, achieving the highest value in the extract prepared using the high temperature for 30 min. The same trend was noticed for the flavonoid concentration in the extracts (7.14-8.48 mg catechin equivalent/g of dried plant material): macerate after 60 min ≤ macerate after 90 min ≤ HAE extract after 15 min ≤ HAE extract after 30 min. Compared to maceration and taking into consideration the industrial requirements such as high extraction yield for a shorter time, HAE could be recommended as a convenient technique for polyphenol and flavonoid extraction from fumitory. This research was an initial step in the production of polyphenol- and flavonoid-rich fumitory extracts aimed to be used for the formulation of foodstuffs and medicines.

Keywords: *fumitory, extracts, polyphenols, flavonoids.*

THE INFLUENCE OF THE BINDER ON THE MORPHOLOGICAL AND TOPOGRAPHICAL CHARACTERISTICS OF THE MODIFIED ELECTRODE SURFACE

Saša Mićin[1], Nadica Ivošević De Nardis[2], Sanja Martinez[3], Maja Levak Zorinc[2], Borislav N. Malinović[4*], Vedrana Špada[5]

[1]*University of Banja Luka, Faculty of Security Sciences, Banja Luka, Bosnia and Herzegovina*
[2]*Ruđer Bošković Institute, Zagreb, Croatia*
[3]*University of Zagreb, Faculty of Chemical Engineering and Technology, Zagreb, Croatia*
[4]*University of Banja Luka, Faculty of Technology, Banja Luka, Bosnia and Herzegovina, borislav.malinovic@tf.unibl.org**
[5]*University of Istria, Research Center METRIS, Pula, Croatia*

Abstract

Modified carbon electrodes with TiO_2 nanoparticles exhibit several advantages over other electrode materials. The electrochemical characteristics of the electrode material depend on various factors, including the type and size of carbon particles, the size of modifier particles, the choice of binder, the preparation method, and the surface morphology and topology. In this paper, the influence of the type of binder on the morphological and topographical characteristics of the surface of modified carbon paste with TiO_2 nanoparticles was investigated. Paraffin oil (PO), tricresol phosphate (TCP), and a mixture of paraffin oil and tricresol phosphate (POTCP) in a 1:1 ratio were used. The surface was characterized using scanning electron microscopy (SEM-EDS) and atomic force microscopy (AFM). The composition of the examined electrode pastes was analyzed using Fourier transform infrared spectroscopy (FTIR). The electrochemical characteristics of the modified electrode paste were analyzed using cyclic voltammetry. The results indicate that the binders used do not have a significant effect on the morphological characteristics of the surface of the modified carbon paste. Changes in surface roughness were observed, with increased roughness leading to a larger electroactive surface area of the electrode. The change in the topographic characteristics of the surface of the electrode paste is caused by the formation of agglomerates of TiO_2 nanoparticles whose size and shape partly depend on the adhesion forces between the binder and the TiO_2 nanoparticles. FTIR spectra for all tested electrode materials did not show additional peaks that would indicate the creation of chemical bonds between individual components of the electrode material. The test results point to the importance of the influence of the topographic characteristics of the surface of carbon electrodes modified with TiO_2 nanoparticles on the electrochemical characteristics of the electrode itself.

Keywords: *Modified carbon electrode, TiO_2 nanoparticles, roughness, paraffin oil, tricresol phosphate.*

ADVANCES IN UNDERSTANDING THE USE OF UNIT OPERATIONS IN METALLURGY FOR THE TREATMENT OF BAUXITE RESIDUES

Srećko Stopić[1*], Duško Kostić[1,2], Mitar Perušić[2], Vladimir Damjanović[3], Radislav Filipović[2,3], Bernd Friedrich[1]

*[1]IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Aachen, Germany, sstopic@ime-aachen.de**
[2]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina,
[3]Alumina d.o.o., Karakaj, Zvornik, Bosnia and Herzegovina

Abstract

Bauxite residue, commonly known as red mud is byproduct of the Bayer process for alumina production. It presents both environmental challenge as well as opportunity for resource recovery. With high content of iron, titanium, and other valuable metals such as gallium, scandium and vanadium, red mud has gathered significant attention as a potential secondary resource. This study investigates advanced metallurgical operations for the efficient processing of red mud with focus on reduction, separation, and leaching techniques to extract critical materials. The reduction of red mud was performed using different approach, including carbothermic reduction, hydrogen reduction in tubular furnace and rotary kiln as well as hydrogen plasma reduction. These reduction processes facilitate the conversion of iron oxides to metallic iron, enabling easy separation from the slag through physical methods. The resulting slag is enriched in titanium and other oxide compounds, which cannot be reduced by carbon or hydrogen. Slag was then subjected to a leaching process in a sulfuric acid medium under oxidizing and high-pressure conditions. This innovative leaching method effectively dissolves titanium, producing titanium oxysulfate as a valuable intermediate for industrial applications such as pigment production and advanced material synthesis. This work demonstrates a comprehensive approach to red mud processing by integrating advanced reduction technologies and optimized leaching conditions, addressing environmental sustainability while unlocking the economic potential of this industrial waste. The findings highlight the viability of recovering iron and titanium-oxide as marketable products, contributing to the circular economy and reducing the environmental impact which is associated with red mud disposal.

Keywords: *bauxite residue, reduction, leaching, iron recovery, titanium oxide.*

ENVIRONMENTAL AND ECONOMIC CRITERIA FOR MULTICRITERIA ANALYSIS OF THERMAL INSULATION MATERIALS ON EXAMPLE OF RECYCLED TEXTILE AND CONVENTIONAL MATERIALS

Đorđe Vojinović[1*], Ana Jojić[2]

[1]*University of Banja Luka, Faculty of Technology, Banja Luka, Bosnia and Herzegovina, djordje.vojinovic@tf.unibl.org**

[2]*Ministry of Defence and Armed Forces of Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina*

Abstract

Making decisions, i.e. the need for them, is constantly present in all areas of human activity, regardless of whether it is an individual, a group of people, a company, a state, etc. Therefore, the scientific study of the decision-making process, i.e. the development of decision-making theory as a separate scientific discipline, is fully justified. In real problems, requirements are often set for the achievement of multiple interrelated goals, where each individual goal is influenced by a large number of factors. Therefore, the decision is made by analyzing the most important factors at the moment - choosing the appropriate criteria and the desire to achieve as many goals as possible at the same time. a key role in MCDA analysis is the selection of appropriate criteria that should provide quantitative or qualitative information in a simple and clear way. The textile industry is the second most environmentally polluting industry in the world after the petroleum industry. Approximately 25% of global chemicals are used in textile production, around 10% of the world's CO_2 emissions are generated by the textile industry, and it consumes more water than any other industry. Annually, about 92 million tons of textile wastes are produced, with only an estimated 10-30% of the waste being recycled. Textile waste can be reused or recycled using various methods for thermal insulation materials.

The aim of this study is to analyze and compare recycled thermal insulation materials with conventional thermal insulation materials based on economic and environmental criteria. By using the DEXi software tool, a multicriteria analysis was conducted between recycled textile and conventional thermal insulation materials based on economic and environmental criteria. In terms of economic and environmental criteria, conventional thermal insulation materials have an advantage over thermal insulation materials made from recycled textiles.

In conclusion, the decision on which option is better depends on the specific requirements of the project. If sustainability is a key priority, based on all available information, thermal insulation made from recycled textiles is the better choice. However, if priorities are focused on heat insulation, moisture resistance, and durability, EPS is currently the better option. According to the planned scenario, there is a possibility that the efficiency of both thermal insulation materials can be balanced through additional research and improvement.

Keywords: *multicriteria analyses tools, DEXi, recycling, thermal insulation, EPS, textile industry, environmental pollution.*

STRUCTURAL INTEGRITY ASSESSMENT OF PRESSURE VESSELS USED IN PROCESS INDUSTRY - RISK BASED APPROACH

Aleksandar Sedmak[1*], Snežana Kirin[2], Igor Martić[2], Tamara Golubović[2]

[1]*University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia, asedmak@mas.bg.ac.rs**

[2]*Innovation Center of the Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia*

Abstract

Risk based approach to assess structural integrity of pressure vessel in process industry is presented, taking into account EU PED 2014/68 and API 581, and using basic fracture mechanics parameters. Failure Assessment Diagram (FAD) is applied to assess likelihood of failure of two spherical storage tanks, one for vinyl chloride monomer (VCM), the other one for ammonia. Using consequence estimation, the risk matrix is constructed, enabling managers to make decisions using risk as defined by engineers.

Keywords: *Structural integrity, Pressure vessels, Process industry, Risk based approach.*

ANALYSIS OF GLUTEN PROTEIN AFTER REPLACING PART OF WHEAT FLOUR WITH AMARANTH IN MUFFINS

Vesna Gojković Cvjetković[1*], Dragana Škuletić[1], Željka Marjanović-Balaban[2], Danijela Rajić[1], Milan Vukić[1], Milenko Smiljanić[1], Dragan Vujadinović[1]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Bosnia and Herzegovina, vesna.gojkovic@tfzv.ues.rs.ba**
[2]*University of Banja Luka, Faculty of Forestry, Bulevar vojvode Petra Bojovića 1A, Banja Luka, Bosnia and Herzegovina*

Abstract

Amaranth belogs to the group of pseudocereals. This pseudocereal is rich in proteins and does not contain gluten. Therefore, it is suitable for people on a gluten-free diet. In recent years, the number of people suffering from celiac disease or who are allergic to gluten has been increasing every day. The aim of this paper was to examine how the partial replacement of wheat flour with amaranth in muffins, in different ratios, affects gluten proteins (gliadins and glutenins). The aim was also to examine how the storage time of muffins for 0, 2 and 4 weeks affects gluten proteins (gliadins and glutenins). Gliadin protein was extracted with 70% (v/v) ethanol, and glutenin with 50% (v/v) 1-propanol with the addition of Tris-HCl (0.05 mol/l), urea (2 mol/l) and dithioerythritol (1%). Gluten protein separation was performed by reverse-phase high-pressure liquid chromatography (RP-HPLC). Absorbance measurement was at 210 nm. After separation, the total amount of gliadin and glutenin protein was determined, as well as the amount of protein within the fractions. Based on the obtained results, the highest amount of gliadin protein was obtained from muffin samples made from 100% wheat flour and stored for 4 weeks and is Xav=20.33, and the lowest amount of protein was obtained from muffin samples made from 50% wheat flour and 50% amaranth and stored for 0 weeks and is Xav=12.00. The highest amount of glutenin protein was obtained from muffin samples made from 100% wheat flour and stored for 4 weeks (Xav=26.67), and the lowest amount was obtained from samples made from 25% wheat flour and 75% amaranth and stored for 0 weeks (Xav=17.33).

Keywords: *gliadins, glutenins, amaranth, muffins, RP-HPLC.*

BATCH DISTILLATION OF MULTICOMPONENT MIXTURES: SEMI-RIGOROUS MODEL WITHOUT HOLDUPS

Adnan Hadžihasanović[1*], Muhamed Bijedić[2]

*[1]Plamingo doo, Gračanica, Bosnia and Herzegovina, adnan.h2012@gmail.com**
[2] University of Tuzla, Faculty of Technology Tuzla, Department of Chemical Engineering, Tuzla, Bosnia and Herzegovina

Abstract

The semi-rigorous model without holdups and the semi-rigorous model with minimum holdups give almost the same results. However, the former uses integration step 0.1 h and the latter integration step 0.00001 h. This, and the fact that a semi-rigorous model describes the dynamics of the batch distillation process more reliably than a shortcut model, makes the semi-rigorous model without holdups more suitable for dynamic optimization of the process. For the calculation of the composition in the condenser, at each step of time, a modified Levenberg-Marquardt method is used. The computer implementation of the above algorithm is performed in the FORTRAN programming language. Imposing the constraints is avoided by introducing the composition normalization.

Keywords: *batch distillation, mathematical modeling, multicomponent mixtures.*

PROJECT OF METEOROLOGICAL STATION BASED ON ESP32 MICROCONTROLLER

Božo Ilić[1*], Branko Savić[1], Jovan Vujić[2], Dragan Rastovac[1]

[1]*The Higher Education Technical School of Professional Studies Novi Sad, Školska 1, Novi Sad, Serbia, ilic@vtsns.edu.rs**
[2]*Jugoinspekt Beograd a.d., Čika Ljubina 8/V, Belgrade, Serbia*

Abstract

Weather stations, thanks to precise sensors, enable the collection of meteorological data (on temperature, humidity, pressure, etc.) in real time and their display in the form of diagrams and reports, which allows better observation of weather trends and giving forecasts. Choosing an adequate location for the meteorological station is extremely important for obtaining accurate measurement results. The location should be chosen so that it is away from trees, buildings or other obstacles, as well as from reflective surfaces such as asphalt or water that can affect the accuracy of the measurement. The weather station should be placed on a high ground to avoid errors caused by odors and exhaust gases. The ideal height is from 1.5 to 2 meters. Plastic materials that are resistant to atmospheric influences were selected for the construction of the housing. For measuring meteorological parameters, the following were selected: temperature and humidity sensor, pressure sensor, wind sensor, precipitation sensor, UV radiation sensor, solar radiation sensor, visibility and fog sensor. The weather station can also measure the level of air pollution, which enables citizens to be informed about unfavorable conditions in a timely manner. Particle sensors (PM2.5 and PM10) and gas sensors (carbon dioxide CO_2, carbon monoxide CO, nitrogen dioxide NO_2, sulfur dioxide SO_2, methane CH_4, ammonia NH_3, radon) were selected for this. Multiple microcontrollers (Arduino, ESP8266, ESP32, Raspberry Pi, etc.) can be used for a weather station project. An ESP32 microcontroller was selected, which enables wireless communication via Wi-Fi and Bluetooth. It has more GPIO pins than the Arduino UNO. It is ideal for IoT (Internet of Things) projects and remote monitoring. Since there is usually no Wi-Fi network at the location where the meteorological station is located, the GSM/GPRS SIM 800 module connected to the microcontroller via serial communication (TX, RX pin) was selected for data transmission over the Internet. A lithium-ion battery was chosen to power the microcontroller and sensors, which is replenished with electricity from the photovoltaic panel via a voltage regulator. For the needs of the metrology station project based on the ESP 32 microcontroller, the ThingSpeak platform was chosen, as a service that is often used for IoT projects based on ESP 32 microcontrollers.

Keywords: *Meteorological station, ESP32 microcontroller, Internet of Things, ThingSpeak, STEAM project.*

EFFECT OF TEMPERATURE AND CHROMIUM CONTENT ON TENSILE PROPERTIES AND FRACTURE MECHANICS PARAMETERS OF CR-MO STEEL WELDED JOINTS

Nikola Kostić[1*], Milivoje Jovanović[2], Ivica Čamagić[1], Živče Šarkoćević[1], Zijah Burzić[3], Aleksandar Sedmak[4]

[1] *University of Priština, Faculty of Technical Sciences, Kneza Miloša 7, Kosovska Mitrovica, Serbia, kosticn83@gmail.com**

[2] *University of Priština, Academy of Applied Studies, Dositeja Obradovića bb, Leposavić, Serbia*

[3] *University of Belgrade, Military Institute of Techniques, Ratka Resanovića 1, Belgrade, Serbia*

[4] *University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia*

Abstract

Cr-Mo steels A-387 Gr. B and SA-387 Gr. 91 are intended for the production of pressure vessels, steam pipelines and gas installations in the chemical and petrochemical industry, as well as thermal power plants, which work in conditions of elevated temperature and corrosive environment. Due to their exceptionally good mechanical properties, as well as their excellent resistance to the presence and propagation of cracks in operational conditions, their use also results in significant material savings compared to conventional steels. This paper presents an analysis of the influence of temperature and Cr content on the measure of resistance to brittle fracture of the welded joint of Cr-Mo steel from the aspect of applying parameters obtained from tensile tests and parameters obtained from fracture mechanics tests.

Analyzing the test tube tensioning results of butt-welded joint, it can be seen that with an increase in the test temperature, there is a decrease in the value of the yield stress and tensile strength (for both welded joints), an increase in the elongation of the welded joint of steel A-387 Gr. B and elongation reduction in the welded joint of steel SA-387 Gr. 91. All test tubes broke in the parent metal (at both welded joints), which gave us the tensile characteristics of the parent metal (PM). Based on the obtained test results of test tubes extracted from PM, weld metal (WM) and heat affected zone (HAZ), it can be seen that with increasing test temperature there is a decrease in the value of the critical J_{Ic} integral, hence fracture toughness K_{Ic}. Likewise, the value of the critical crack length a_c decreases or changes slightly in the welded joint of steel A-387 Gr. B and increases in the welded joint of steel SA-387 Gr. 91.

Keywords: *welded joint, crack, tensile properties, fracture toughness in plane deformation, critical crack length.*

MATHEMATICAL MODELING OF NICKEL REMOVAL BY COAGULATION AND FLOCCULATION PROCESS

Tijana Đuričić[1*], Dajana Dragić[1], Sanda Pilipović[1], Aleksandra Borković[1], Dijana Drljača[1], Draženko Bjelić[1], Borislav Malinović[1]

[1] *University of Banja Luka, Faculty of Technology, Stepe Stepanovića 73, Banja Luka, Bosnia and Herzegovina, tijana.djuricic@tf.unibl.org**

Abstract

In this study, the effects of coagulant and flocculant concentrations, as well as their interaction on the efficiency of Ni removal through the coagulation and flocculation process of real wastewater from the metal industry were examined. A 3^2 factorial design was used for the design of the experiment, with two independent variables: coagulant concentration (Factor A) and flocculant concentration (Factor B), each factor at three concentration levels. The dependent variable that was monitored after the treatment was the Ni removal efficiency (%) (Response – R_1). In the coagulation/flocculation wastewater treatment, ferric chloride (80 mg/L, 120 mg/L, 160 mg/L) was used as the coagulant, and polyacrylamide Superfloc A-110 (5 mg/L, 10 mg/L, 15 mg/L) was used as the flocculant. Statistical analysis of the results, analysis of variance (ANOVA), showed that there was no statistically significant interaction between the two factors in the tested concentration range in the case when precipitation at pH 10 was previously performed on the sample of wastewater. A linear empirical model was developed for the coagulation and flocculation process to estimate Ni removal efficiency. The addition of flocculant had a greater effect on Ni removal efficiency compared to the coagulant concentrations used in the process. This was also confirmed by the residual Fe concentration in the samples of water after the treatment. The developed linear model and graphical representation of developed model allowed the determination of optimal conditions for Ni removal efficiency through the coagulation and flocculation process. The maximum overall Ni removal efficiency of 96.55%, for an initial Ni concentration of 7.07 mg/L in wastewater, was achieved by applying the optimal $FeCl_3$ dose of 80 mg/L, with an optimal flocculant concentration of 15 mg/L, under the following conditions of coagulation/flocculation treatment: pH 8, temperature 19.5°C, with prior precipitation at pH 10 and separation of the primarily formed sludge.

Keywords: *coagulation, flocculation, empirical model, Ni removal, three-level factorial design, wastewater.*

IMMOBILIZATION OF CRUDE LACCASE ONTO CHITOSAN BEADS TO ENHANCE ITS THERMAL AND pH STABILITY

Nevena Ilić[1*], Slađana Davidović[2], Marija Milić[2], Miona Miljković[2], Katarina Mihajlovski[2], Suzana Dimitrijević-Branković[2]

*[1]Innovation Center of Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia, nilic@tmf.bg.ac.rs**
[2]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia

Abstract

Laccases are essential enzymes in various industrial applications, playing a vital role in numerous industrial processes. When immobilized, laccases demonstrate enhanced resistance to environmental changes and offer the added benefit of being easily recoverable and recyclable, which makes them superior to their free forms. Immobilization primarily protects the enzymes from harsh conditions, such as high temperatures and extreme pH levels, significantly improving their stability and lifespan. In this study, we explored the impact of immobilization of crude laccase, isolated from Ganoderma sp., on its thermal and pH stability. The crude laccase was immobilized onto chitosan beads that were pre-activated with 0.5% glutaraldehyde. The study focused on determining the effects of crosslinking and immobilization time on the relative activity of the immobilized enzyme. The thermal and pH stability of both free and immobilized laccase were evaluated over an 8-hour incubation period, across a pH range of 4-8 and temperatures between 20°C and 50°C. The optimal crosslinking time was found to be 2h, which resulted in a relative activity of 34.04% for the immobilized enzyme with a corresponding immobilization time of 2 h. Further optimization of the immobilization time yielded the highest relative activity of 51.31% when the crosslinking time was 2h and the immobilization time was extended to 3 h. In contrast, the lowest relative activity was observed when the crosslinking time was 4 h and the immobilization time was 2h. Both free and immobilized laccases exhibited maximum stability at pH 5 and 20°C. However, immobilized laccase showed superior stability compared to the free form. After an 8-hour incubation at 4°C and pH 5, the immobilized laccase retained 68.25% of its initial activity, whereas the free laccase showed 59.64% of the residual activity. For thermal stability, after 8 h at pH 5 and 20°C, the immobilized laccase demonstrated a residual activity of 58.89%, outperforming the free laccase, which retained 53.29% of the activity. These results underscore the importance of optimizing the immobilization process to enhance the stability of laccases, demonstrating that immobilization significantly improves both thermal and pH stability.

Keywords: *crude laccase, white rot fungi, immobilization, chitosan beads*

THE DISTRIBUTION OF FLUID FLOWS IN A MODIFIED SPOUT-FLUID BED

Katarina Šućurović[1], Darko Jaćimovski[1], Danica Brzić[2], Mihal Đuriš[1], Zorana Arsenijević[1], Tatjana Kaluđerović-Radoičić[2], Nevenka Bošković-Vragolović[2]

*[1]Institute of Chemistry, Technology and Metallurgy - National Institute of the Republic of Serbia, University of Belgrade, Njegoševa 12, Belgrade, Serbia, katarina.sucurovic@ihtm.bg.ac.rs**
[2]Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade, Serbia

Abstract

The Draft Tube Spout-Fluid Bed (DTSFB) is obtained by inserting a draft tube into a bed and introducing an auxiliary gas flow for aeration in the annular region. A specific modification of this system is a hydraulic barrier, which is an extension of the column from the bottom and whose diameter is smaller than the diameter of the column. The barrier prevents the mixing of the spouting and aeration gas streams as well as the bypass of the gas from the annulus to the draft tube. Because of the great potential of the DTSFB with the hydraulic barrier for other applications (chemical reactions, CO2 capture by adsorption), it is very important to understand the gas distribution between the draft tube and the annulus. In this work, the influence of the aeration gas flowrate, the draft tube diameter and entrainment zone height on the gas distribution between the annulus and the draft tube was investigated. The experimental system consisted of a cylindrical column with a diameter of 100 mm and a hydraulic barrier with a diameter of 60 mm and a draft tube with a diameter of 20 mm and 25 mm at variable distance from the bottom. Spherical glass particles were used in the experiments and air was used as a spouting agent. The bypass of spouting gas into the annulus increases with increasing height of the entrainment zone and decreases with increasing flow rate of the aeration fluid and the draft tube diameter. It was found that due to the presence of a hydraulic barrier, a very small portion of the aeration fluid from the annulus enters the draft tube only at maximum flow rate of the aeration fluid and that the bypass of the aeration fluid into the draft tube increases with increasing draft tube diameter and decreasing height of the entrainment zone. Based on experimental results, optimum operating conditions were determined in which there is no gas bypass from the annulus to the draft tube.

Keywords: *spout-fluid bed,hydraulic barrier, spouting gas bypass, aeration gas bypass*

RUBISCO PROTEIN FROM AGRICULTURAL WASTE WITH ENHANCED SOLUBILITY FOR COMPLEXATION WITH GUM ARABIC

Bojana Balanč[1*], Predrag Petrović[1], Tamara Đukić[1], Verica Đorđević[2], Jelena Mijalković[2], Nataša Šekuljica[2], Viktor Nedović[3], Branko Bugarski[2], Zorica Knežević-Jugović[2]

[1]*University of Belgrade, Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia, bisailovic@tmf.bg.ac.rs**
[2]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*
[3]*University of Belgrade, Faculty of Agriculture, Nemanjina 6, Belgrade, Serbia*

Abstract

Agricultural waste holds significant potential as a source of nutritionally valuable components but remains largely underutilized. Oilseed crop leaves, in particular, are rich in proteins, with the enzyme RuBisCO comprising a major portion of the protein fraction. However, RuBisCO extracted using standard methods often exhibits limited solubility, which can hinder its interaction with other polymers in various applications. This study aimed to extract RuBisCO from pumpkin leaves using a combination of isolation techniques—salting out with ammonium sulfate followed by three cycles of acidic precipitation. The extracted protein was further characterized using the Kjeldahl method, FTIR spectroscopy, and isoelectric point determination. Results showed a protein purity of over 90%, with the FTIR spectrum confirming the presence of characteristic peptide bands and a small amount of residual ammonium sulfate. The extracted protein demonstrated improved solubility compared to fractions obtained using individual methods, with a relatively high isoelectric point of approximately 5.39. The obtained protein was then used to form complexes with gum arabic, an acidic polysaccharide. Various protein-to-polysaccharide ratios were tested (1:2, 1:1, 2:1, 3:1, 5:1, and 10:1) as the ratio is one of the most important parameters affecting complex formation by modifying the charge balance in the complexes. Complex formation was monitored by changes in ζ-potential across different pH levels (8.5 to 2.0), with the highest yield occurring at the isoelectric point of the protein-polysaccharide mixture. The isoelectric points for all tested ratios were determined, showing a neutral ζ-potential between 2.95 and 4.39. Higher gum arabic content resulted in a lower isoelectric point; however, the values remained within an acceptable range, ensuring the complexes' suitability as carriers for vitamins or other sensitive compounds.In conclusion, the successful extraction and enhanced solubility of RuBisCO from pumpkin leaves, combined with the formation of protein-polysaccharide complexes, demonstrates the potential of agricultural waste as a valuable source of functional biomaterials for various applications.

Keywords: *protein, RuBisCO, agricultural waste, gum arabic, complexation, ζ-potential*

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COMPOSITE HYDROGEL WITH SILVER NANOPARTICLES AND MUSHROOM B-GLUCAN EXTRACT AS POTENTIAL WOUND DRESSING

Tomislav Marković[1], Jasmina Stojkovska[1], Jovana Zvicer[1], Bojana Balanč[2], Aleksandra Jovanović[3], Branko Bugarski[1], Predrag Petrović[2]

[1]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia
*[2]University of Belgrade, Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia, bisailovic@tmf.bg.ac.rs**
[3]University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia

Abstract

Puffballs are a group of macrofungi that produce enclosed, globose fruiting bodies. When young, they have a solid white interior (gleba), which turns into a powdery, brown spore-bearing mass as they mature. These fungi have been used in folk medicine worldwide, primarily as wound dressings. Since fungal β-glucans are known to aid in wound healing, this study utilized the β-glucan-enriched fraction from the pestle puffball (Lycoperdonexcipuliforme) to synthesize silver nanoparticles (AgNPs), which were incorporated into alginate-based hydrogels for potential wound treatment. Silver nanoparticles were synthesized via a hydrothermal method using silver nitrate, sodium citrate, and varying concentrations of β-glucan extract as stabilizing agents: 0.4 mg/mL (S1), 0.8 mg/mL (S2), 1.6 mg/mL (S3), and 2.4 mg/mL (S4). Particle size was approximately 30 nm for all samples, with zeta potential ranging from -22.3 to -13, increasing with the extract concentration. A one-year stability study at room temperature showed minimal changes in UV-VIS spectra and particle size distribution, despite relatively low zeta potential, suggesting steric stabilization by β-glucan extract. To assess stability in physiological conditions, samples were diluted in 0.85% NaCl solution, and size distribution and UV-VIS absorption were monitored for seven days. Sample S4 exhibited the highest stability and was selected for further experiments. Its antibacterial activity was tested against common wound-infecting bacteria, Staphylococcus aureus and Pseudomonas aeruginosa, using the broth microdilution method. The minimum inhibitory concentration (MIC) was 35 μg/mL for both strains, with minimum bactericidal concentrations (MBC) of 120 μg/mL and 240 μg/mL, respectively. S4 was then used to prepare an alginate-based hydrogel, and a release study was conducted to assess the product's potential efficacy. The hydrogel was made by mixing equal volumes of AgNP suspension and 4% sodium alginate solution, with the addition of 4% $CaCl_2$ solution in a circular mold. The release study, conducted in TRIS buffer (50 mM) with 0.85% NaCl at varying pH levels over 72 hours, showed pH-dependent release. At pH 8.5 (similar to that of infected wounds), an effective AgNP concentration (~35 μg/mL) was reached after ~3 hours, increasing to ~100 μg/mL after 72 hours. These results suggest that fungal β-glucans are excellent stabilizing agents for AgNPs and that the combination of β-glucans' immunostimulatory and AgNPs' antibacterial properties may have a synergistic effect in the treatment of infected wounds. Hydrogel containing AgNPs both prolonged, and pH-dependent release of the particles.

Keywords: *wound dressing, hydrogel, silver nanoparticles, β-glucan, mushrooms, puffballs*

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MODELING THE EXTRACTION PROCESS OF GALLIC ACID FROM POMEGRANATE PEEL IN A PACKED BED WITH RECIRCULATION

Darko Jaćimovski[1*], Katarina Šućurović[1], Dunja Šijaković[2], Jelena Živković[3], Katarina Šavikin[3]

*1University of Belgrade, Institute of Chemistry, Technology and Metallurgy – National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia, darko.jacimovski@ihtm.bg.ac.rs**
2Innovation Center, Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade, Serbia
3University of Belgrade, Institute for Medicinal Plant Research "Dr Josif Pancic", Tadeuša Košćuška 1, Belgrade, Serbia

Abstract

The extraction of gallic acid from the pomegranate peel was carried out in a column with a diameter of 40 mm, in which pomegranate peel grains with a diameter of 2 mm were placed in a packed bed. The extraction fluid is recirculated through the system using a centrifugal pump. The fluids used in the extraction are: water, ethanol:water=50:50 and ethanol:water=96:4 (vol%). The experimental equipment has a temperature control system. The temperatures at which the experiment was carried out are: 35, 50 and 65˚C. raction, as well as the models themselves. The models used in the analysis are: film theory, non-stationary diffusion. The equations used to describe the extraction are Peleg's equation and Ponomarjev's equation. The extraction parameters for gallic acid and the diffusion coefficient were determined. A model for the dependence of the mass transfer coefficient on temperature was established, as well as a criterion equation describing the extraction of gallic acid from the pomegranate peel. The yield of gallic acid in solution is good.

Keywords: *gallic acid, extraction, packed bed, mass transfer*

APPLICATION OF 2D AND 3D DIGITAL IMAGE CORRELATION IN TESTING PRESSURE EQUIPMENT AND RELATED MATERIALS

Nenad Mitrovic[1*], Milan Travica[1], Aleksandra Mitrovic[2]

[1]*University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia, nmitrovic@mas.bg.ac.rs**
[2]*University "Union - Nikola Tesla", Faculty for Information Technology and Engineering, Cara Dušana 62-64, Belgrade, Serbia*

Abstract

Digital Image Correlation (DIC) method, including both 2D and 3D DIC, plays an important role in testing and evaluating pressure equipment integrity, as well as materials used in pressure equipment. The 2D DIC method, employing a single-camera setup, is particularly suited for assessing surface deformation and strain distribution in simpler geometries and thin-walled pressure components under various loading conditions. This technique efficiently identifies localized strains, surface defects, and initial crack formation, crucial for maintaining the structural integrity of pressure vessels, piping, and storage tanks. Due to its ease of implementation, 2D DIC is often applied in laboratory tensile tests, pressure cycle tests, and validation of finite element models for flat or nearly flat pressure equipment surfaces.

On the other hand, 3D DIC, utilizing a stereo, dual-camera arrangement, significantly expands the measurement capabilities, allowing accurate assessment of complex, three-dimensional deformation fields present in curved or intricate geometries typical of pressure equipment. The method effectively captures out-of-plane displacements and complex strain distributions arising under internal pressure conditions, thermal loading, and fatigue tests, that are common operational scenarios for pressure equipment. The advanced spatial measurement capabilities of 3D DIC enable precise identification of critical regions prone to failure, including weld joints, nozzles, and geometrical discontinuities. Consequently, 3D DIC provides critical insights into material behavior and structural response, enhancing safety, performance, and reliability in pressure equipment.

Integrating DIC methodologies with advanced data processing techniques, further improves the predictive capabilities and accuracy of strain measurements. These advancements facilitate early damage detection and real-time structural health monitoring, significantly reducing the risk of unexpected equipment failures. Ultimately, the focused application of 2D and 3D DIC in pressure equipment testing supports more efficient design optimization, maintenance scheduling, and regulatory compliance, reinforcing its importance within the domain of structural integrity assessment.

Keywords: *Digital Image Correlation, Pressure Equipment, Strain Measurement, Structural Integrity, Material Testing*

GRANULATED ACTIVATED CARBON AS AN EFFICIENT ADSORBENT FOR REMOVAL OF ORGANIC MATTER FROM WATER

Zoran Petrović[1]*, Aleksandra Radulović[2], Sanja Panić[3], Sabina Begić[4], Dragana Kešelj[1], Mirjana Petronijević[3]

*[1]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina, zoran.petrovic@tfzv.ues.rs.ba**
[2]Institute of General and Physical Chemistry, Studentski trg 12/V, Beograd, Republic of Serbia
[3] University of Novi Sad , Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Republic of Serbia
[4]Faculty of Technology, University of Tuzla, Urfeta Vejzagića 8, Tuzla,Bosnia and Herzegovina

Abstract

This study examined the characteristics of granulated activated carbon (GAC) as an adsorbent for the removal of organic matter from the surface water of the Jala River. The adsorbent was characterized by XRD, FTIR, Raman spectroscopy, BET and SEM/EDS methods, while a detailed physicochemical characterization was performed for the water sample. The adsorption process was carried out under the following laboratory conditions: T(water) = 25 °C, individual doses of GAC of 1, 2 and 4 g/L, stirring speed 200 rpm and time 60 minutes. The research results showed that GAC has good structural, textural and morphological characteristics and that it can be successfully applied to remove organic matter from water (70.53%) using the lowest dose.

Keywords: *granulated activated carbon, adsorption, organic matter, water treatment*

THE IMPACT OF PACKAGING TYPE ON SOME PHYSICAL-CHEMICAL AND SENSORY CHARACTERISTICS OF APPLE BRANDY

Zoran Petrović[1], Tamara Mutabdžija[1], Tatjana Botić[2], Pero Dugić[3], Nebojša Vasiljević[1], Marina Jokić[1]

*[1]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34A, Zvornik, Republic of Srpska, Bosnia and Herzegovina, zoran.petrovic@tfzv.ues.rs.ba**
[2]University of Banja Luka, Faculty of Technology,Vojvode Stepe Stepanovića 73, Banja Luka, Republic of Srpska, Bosnia and Herzegovina;
[3]Higher Medical School of Health Doboj, Vojvode Sinđelića 45, Doboj, Republic of Srpska, Bosnia and Herzegovina

Abstract

The Republic of Srpska has favorable climatic conditions and quality soil for growing various types of fruit (plums, apples, pears, quinces, etc.), with a large portion of this fruit being used to produce high-quality domestic brandies. The production of brandies in rural households is carried out in distillation devices (pot stills) with a capacity of up to 100 L. For the aging or maturation of brandies, storage, and commercial sales, different types of packaging made of wood, glass, and polymer materials are used.

This work examined the physical-chemical and sensory characteristics of apple brandy made from the "Jonagold" variety after aging and maturation in glass and polyethylene terephthalate (PET) packaging for two years. These characteristics were determined using methods prescribed by the relevant regulations, and for determining the content of volatile substances (aldehydes, higher alcohols, ketones, ethyl acetate), the GC-FID method was employed. Sensory evaluation was conducted using an appropriate questionnaire (acceptability test) by 10 individuals who consumefruit brandies.

The test results showed that the alcohol content in the tested brandy samples decreased, with the loss of alcohol, sugar content, total volatile substances, and total acids being higher in the brandy sample from the PET bottle. The content of total esters and total aldehydes was higher in the brandy sample from the glass bottle. Sensory tests showed that the brandy in both glass and PET bottles was clear and had an appropriate color (no cloudiness), and the taste and aroma of the brandy in the glass bottle were slightly more acceptable than those in the PET bottle. The analysis of the results indicated that a high-quality brandy was obtained from the mentioned apple variety using older distillation equipment, and for aging and storing it, glass packaging is preferable.

Keywords: *apple brandy, physical-chemical characteristics, sensory characteristics, GC-FID, glass and PET bottles*

INVESTIGATION OF KINETICS OF ADSORPTION OF METHYLENE BLUE ON ACTIVATED CARBON

Nebojša Vasiljević[1,2*], Sanja Panić[2], Goran Tadić[1], Jelena Vuković[1], Nataša Novaković[1], Vladan Mićić[1]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34A, Zvornik, Republic of Srpska, Bosnia and Herzegovina, nebojsa.vasiljevic@tfzv.ues.rs.ba**
[2]*University of Novi Sad, Faculty of Technology, Cara Lazara 1, Novi Sad, Republic of Serbia*

Abstract

This paper investigated the adsorption kinetics of methylene blue (MB) on activated carbon. Tests of the adsorbent (granulometric composition and FT-IR analysis) showed that the adsorbent has a wide distribution of particles (5-250 μm) and that the most frequent vibrations are caused by N=C=N stretching, C=C=C stretching, metal-oxygen vibrations (e.g. Fe–O) and heteroatomic vibrations (C-Cl or C-Br). Increasing the dose of adsorbent and decreasing the initial concentration of methylene blue increases the efficiency of adsorption, while the most intensive adsorption takes up to 10 min. The adsorption process is pseudo-second-order, which indicates that adsorption occurs due to chemical interactions between adsorbate and adsorbent. The results indicate that the use of activated carbon achieves a high level of MB removal, especially under optimized conditions.

Keywords: *Activated carbon; Methylene blue; Adsorption kinetics; Pseudo-second order; FT-IR analysis; Granulometric analysis*

MODELING WATER SORPTION CAPACITY OF SILICA GEL

Dragana Kešelj[1]*, Dragica Lazić[1], Željana Bogićević[1], Zoran Petrović[1], Dijana Drljača[2]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina; dragana.keselj@tfzv.ues.rs.ba**
[2] *University of Banja Luka, Faculty of Technology, Vojvode Stepe Stepanovića 73, Banja Luka, Bosnia and Herzegovina*

Abstract

Silica gel is a widely used desiccant with a high water sorption capacity, influenced by factors such as specific surface area, pore volume, and pore size. This study develops mathematical models using multiple linear regression analysis (MLRA) to predict the water sorption capacity of silica gel based on experimental data. Independent variables include relative humidity (RH), specific surface area (SpBET), pore volume (Vp), and mean pore diameter (d). Pearson's correlation coefficient reveals strong positive correlations between water sorption capacity (w) and RH, and moderate correlations with SpBET, Vp, and d. Additionally, SpBET is strongly correlated with both Vp and d, while Vp and d also show a strong relationship. Two MLRA models were developed to predict sorption capacity: one based on RH and SpBET, and the other on RH and Vp. The R-squared values for these models were 0.886 and 0.902, respectively, indicating they are strong predictors of water sorption capacity in silica gel.

Keywords: *multiple linear regression analysis (MLRA), water sorption capacity, silica gel, model*

CHARACTERIZATION OF THE STONE FROM THE JOŠANICA QUARRY AND THE POSSIBILITY FOR ITS APPLICATION

Dragica Lazić[1*], Dragana Kešelj[1], Gordana Ostojić[2], Milenko Smiljanić[1], Nebojša Vasiljević[1,3], Pavle Lončar[1]

*[1]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34A, Zvornik, Republic of Srpska, Bosnia and Herzegovina; dragica.lazic@tfzv.ues.rs.ba**
[2] Alumina factory "Alumina D.O.O.", Karakaj, Zvornik, Republic of Srpska, Bosnia and Herzegovina
[3] University of Novi Sad, Faculty of Technology, Bulevar cara Lazara 1, Novi Sad, Serbia

Abstract

Stone samples were sampled from three fields: Field A, Field B, and Field C. In this work, chemical and mineralogical analysis of the stone was performed. The chemical analysis of the stone was done by volumetric, complexometric, spectrophotometric, gravimetric and X-ray fluorescence analysis (XRF). Mineralogical analysis was done by XRD analysis. Analyzes show that calcite is the dominant mineral in most samples, while dolomite is significantly present in some samples. Chemical analysis shows that calcium dominates in samples 2 (Field B) and 3a and 3b (Field C), with only negligible amounts of magnesium. In contrast, samples 1a, 1b, and 1c (Field A) contain a significant amount of magnesium. According to the $MgCO_3$ content, the presence of dolomite in the stone was calculated. The content of $CaCO_3$ bound in dolomite is lower than that present in the stone sample, which confirms that it is present in some other form. According to the dolomite content, samples 1a, 1b, and 1c (Field A) are classified as limestone-dolomite, while samples 2 (Field B) and 3a and 3b (Field C) are classified as limestone due to their high calcium carbonate content. Mineralogical analysis confirms the chemical analysis.

Keywords: *Carbonate rocks; Calcium carbonate; Calcite; Dolomite; Magnesium carbonate.*

SOIL THERMAL PROPERTIES DETECTION USING INVERSE HEAT TRANSFER ANALYSIS

Khalid Shibib[1*]

[1]*Ashur University, College of Engineering, Renewable Energy Department, Baghdad, Iraq, profkhalidsalem@gmail.com**

Abstract

In this work, the inverse heat transfer analysis (IHTA) utilizing the Finite Element Method (FEM) has been used to detect the thermal properties of the soil where in situ soil temperature (ST) measurements together with that obtained theoretically are used in the solution. The initial values of the unknowns such as the soil thermal diffusivity are proposed and together with the theoretical and experimental values of the temperature, an iteration procedure is used to obtain the soil thermal diffusivity. The necessary information about the temperatures could be detected remotely where the surface temperatures of the soil is measured by a thermal camera assume the accuracy of the readings is the main affecting factor on the accuracy of value of the detected property. Using the same procedure, the work could be extended to detect the thermal conductivity, specific heat of the soil and its density. The only limitation in increasing the number of detected properties (output data) is the accuracy of the measurement device and the number of readings. The proposed method could achieve a good nearby result comparing with experimental measurements and can be used with confidence assume the output data is found to be depend mainly on the accuracy of temperature readings.

Keywords: *soil temperature; inverse heat transfer analysis; thermal properties.*

POLYMERIC NANOMICELLES FOR CANCER NANOMEDICINE - REVIEW

Aleksandra Porjazoska Kujundziski[1*], Dragica Chamovska[2,3]

[1]*International Balkan University, Faculty of Engineering, Makedonsko Kosovska Brigada, Skopje, North Macedonia, aporjazoska@ibu.edu.mk**
[2]*Saints Cyril and Methodius University of Skopje, Faculty of Technology and Metallurgy, Skopje, North Macedonia;*
[3]*Macedonian Academy of Sciences and Arts, Research Center for Environment and Materials, Skopje, North Macedonia*

Abstract

Cancer is a serious risk to human life. Some predictions show a considerable increase in new cases and deaths by 2050. Chemotherapy and other conventional treatments encounter issues with a lack of specificity, leading to severe side effects on healthy tissues and drug resistance. Nanotechnology with targeted drug delivery shows improved diagnostics and personalized treatments. Biocompatible and biodegradable self-assembling amphiphilic polymeric micelles are attractive vehicles for targeted drug delivery in cancer treatment, increasing the bioavailability and solubility of anticancer drugs in water. However, the transition to market applications meets some difficulties, mainly focused on patient's predisposition to develop drug allergies. Intensive studies are a paradigm for resolving all challenges and facilitating the translation of innovative nanotechnologies into everyday clinical practice. This review paper highlights the importance of applying organic polymeric nanocarriers in cancer nanomedicine.

Keywords: *cancer, drug delivery, nanocarriers, polymeric micelles.*

ROLE OF CHOLESTEROL IN MODIFYING THE PHYSICAL AND STABILITY PROPERTIES OF LIPOSOMES AND IN VITRO RELEASE OF VITAMIN B12

Neda Pavlović[1], Jelena Mijalković[2], Bojana Balanč[1], Nevena Luković[2], Zorica Knežević-Jugović[2*]

[1] *Innovation Center of Faculty of Technology and Metallurgy Ltd., Karnegijeva 4, Belgrade, Serbia;*
[2] *University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia; zknez@tmf.bg.ac.rs**

Abstract

Cholesterol has garnered significant attention in research due to its role in both the structure and the fluidity/rigidity of phospholipid membranes. This property makes it an essential component in liposome formulation. Finding the right ratio of phospholipid-to-cholesterol is important for making a liposome formulation that is stable and works well. This study involved the investigation of various mass ratios between phospholipid and cholesterol. The resulting formulations were characterized in terms of mean particle size, size distribution, and ζ potential. It was observed that as the cholesterol content increased, the mean particle size also increased, with the stability of the suspensions improving up to a certain point, after which stability decreased. The optimal phospholipid-to-cholesterol ratio of 5:1 was identified and chosen for subsequent studies on the encapsulation of vitamin B12. The vitamin was successfully encapsulated in the liposomes (37%), and the controlled release of vitamin B12 under gastrointestinal conditions was demonstrated using the liposomes as a carrier.

Keywords: *cholesterol; liposome; phospholipid; vitamin B12; controlled release.*

LITERATURE REVIEW OF LEAN AND AUTOMATION SYNERGY AS A CORE OF DIGITAL TRANSFORMATION IN MANUFACTURING

Aleksandar Argilovski[1], Radmila Koleva[1*], Trajce Velkovski[1], Bojan Jovanoski[1], Darko Babunski[1]

*[1]Ss. Cyril and Methodius University in Skopje, Faculty of Mechanical Engineering - Skopje, Karpos II bb, Skopje, North Macedonia; radmila.koleva@mf.edu.mk**

Abstract

Introducing automation in manufacturing can lead to increasing efficiency in the assembly process, reducing Lean production waste, and enhancing operator ergonomics. The purpose of combining automation and Lean is to bridge the gap between digital transformation and human-centric automation, ensuring technological evolution together with the operator's well-being while driving industrial optimization, innovation, and efficiency. According to the review, synergy is required; however, challenges remain in effectively aligning automation with Lean principles. This paper aims to analyze the possibilities for integrating automation and Lean management, exploring similarities and the implementation practices to achieve sustainable and competitive manufacturing.

Keywords: *lean, automation, manufacturing, Industry 5.0.*

SOLUBILITY CORRELATION OF SABAH GREEN ROBUSTA COFFEE (*COFFEA CANEPHORA*) BEAN EXTRACT IN SUPERCRITICAL CARBON DIOXIDE EXTRACTION

Sarah Aisyah Khurun Hizar[1], Hasmadi Mamat[1], Rovina Kobun[1], Norliza Julmohammad[1], Siti Faridah Mohd Amin[1], Nor Qhairul IzzreenMohd Noor[1], Mohd Sharizan Md Sarip[2], Azrul Nurfaiz Mohd Faizal[3], Nicky Rahmana Putra[4], Ahmad Hazim Abdul Aziz[1]*

[1] *University Malaysia Sabah, Faculty of Food Science and Nutrition, Kota Kinabalu, Sabah, Malaysia, hazim.aziz@ums.edu.my**

[2] *University Malaysia Perlis, Faculty of Chemical Engineering and Technology, Arau, Perlis, Malaysia*

[3] *University Putra Malaysia Bintulu Sarawak Campus, Institute of Ecosystem Science Borneo, Bintulu, Sarawak, Malaysia*

[4]*Research Center for Pharmaceutical Ingredients and Traditional Medicine, National Research and Innovation Agency (BRIN), Complex Cibinong Science Center–BRIN, Jawa Barat, Indonesia*

Abstract

This research focuses on the solubility correlation of Sabah green Robusta coffee (Coffeacanephora)bean extract using supercritical carbon dioxide (SC-CO_2) extraction. Sabah, the largest coffee-growing area in Malaysia, provides a rich source of Robusta beans for this study. Solubility of coffee bean oil was examined across a range of pressures (10 to 30 MPa) and temperatures (40 °C to 80 °C). The highest solubility, 2.681 mg/g CO_2, was observed at 30 MPa and 40 °C while, the lowest solubility was obtained at 20 MPa and 80 °C about 0.440 mg/g CO_2. Thus, as the temperature increased to 80 °C, the solubility decreased significantly, highlighting the inverse relationship between temperature and solubility in this system. Higher pressure, particularly at 30 MPa, led to increased solubility due to enhanced density and solvating power of SC-CO_2. The experimental solubility data showed a great correlation Chrastil's equation, achieving a percentage error about 3.37% compared with del Valle-Aguilera's equation about 14.57%. These results suggest the Chrastil model's suitability for accurately predicting the solubility of green coffee bean oil in SC-CO_2. The study underscores the potential of SC-CO_2 extraction for use in the food industry as an environmentally friendly, solvent-free method to obtain high-quality extracts from coffee beans. This extraction technique can be extended to other bioactive compounds in food processing, offering a sustainable alternative for industrial applications.

Keywords: *Supercritical carbon dioxide extraction, Green Robusta Coffee Bean, Solubility, Correlation.*

PROCEDURES OF CHEMICAL WASTEWATER PURIFICATION OF GALVANIC CHEMICAL PROCESSES AND QUALITY OF PURIFIED WATER

Vladimir Stjepanović[1*], Božidarka Arsenović[1], Zoran Petrović[2]

[1] *"ORAO" A.D., Šabačkih đaka bb, Bijeljina, Republic of Srpska, Bosnia and Herzegovina, vladimir.stjepanovic@orao.aero**

[2]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Republic of Srpska, Bosnia and Herzegovina*

Abstract

The procedures of chemical purification of wastewater with chemical changes of polluting (harmful) water substances are: neutralization - adjusting the pH value by adding acids or bases; flocculation (flocculation) – joining of dissolved particles into larger flakes that settle; coagulation (coagulation) – addition of chemical substances for faster precipitation; ion exchange - the process of ion exchange between solids (ion exchangers) and liquids (electrolyte solution) and oxidation – removal of various substances from wastewater by oxidants (chlorine, chlorine dioxide, ozone, hydrogen peroxide, etc.). Technological processes of galvanic-chemical protection, according to qualitative-quantitative characteristics, represent one of the most complex pollutants of wastewater. In the processes of galvanic-chemical protection in "ORAO" A.D. Bijeljina, according to the nature of its origin, wastewater contains: free acids and bases; specific contaminants: cyanides, chromates, and nitrates and dissolved heavy metals: Fe, Cd, Ni, Cu, Zn, Ag and others. Applying the shown (and other) procedures, as well as their suitable combination, in the wastewater treatment plant, the quality of purified water is obtained, which, according to the legislation in the Republic of Srpska, can be discharged both into the river recipient and into the public sewage system.

The paper presents some of the segments of complex chemical procedures for the treatment of polluted wastewater, while the obtained results of testing of treated industrial wastewater refer to the sample for the II quarter of 2024.

Keywords: *waste, electroplating, procedures, wastewater, quality.*

PREVALENCE OF FOOD COLORANTS IN REFRESHING NON-ALCOHOLIC BEVERAGES AND BEVERAGES INTENDED FOR CHILDREN

Dragana Ilić Udovičić[1]*, Aleksandra Vasić Popović[1], Jelena Đuričić Milanković[1], Ivana Jevtić[1], Kosana Popović[1]

[1] *Academy of Professional Studies Šabac, Department of Medical and Business-Technological Studies, Šabac, Serbia; dilicudovicic@vmpts.edu.rs**

Abstract

Food colorants are food additives commonly added to foods and beverages to compensate for color loss during processing and exposure to light, air, moisture, and temperature variations. This study evaluates the prevalence of colorants in popular beverages on the local market and those marketed specifically towards children. The study analyzed data from the labels of 162 samples of refreshing non-alcoholic beverages from 24 manufacturers. A total of 62% of the samples contained at least one type of food colorant. The highest percentage of colorant presence were in energy drinks, syrups for refreshing non-alcoholic beverages (90% and 85% of samples, respectively), and fruit juice-based refreshing beverages (71% of samples). The most commonly used colorants were E150d and E160a. Considering the concerns regarding the health effects of certain colorants and the high percentage of beverages containing them, steps should be taken to promote proper nutrition and healthy child development, reducing the intake of synthetic colorants.

Keywords: *food colorants, soft drinks, synthetic colors, marketing to children, food additive.*

MINERAL COMPOSITION AND FLOTATION TESTS OF SULFIDE ORE FROM THE "PLAVICA" DEPOSIT, REPUBLIC OF NORTH MACEDONIA

Goce Zlatkov[1,2*], Katica Radinska[1], Sanja Gacova[1]

[1]*Genesis Resources International LTD, Skopje, Republic of North Macedonia; gzlatkov@yahoo.com**
[2]*International Slavic University, Sveti Nikole, Republic of North Macedonia*

Abstract

The Plavica deposit is located in the northwestern part of the Zletovo ore field, which belongs to the central part of the Kratovo-Zletovo volcanic area in the Republic of North Macedonia. Two mineralogical-geochemical ore zones have been formed in the deposit: upper one - oxide (secondary) with an Au content of 0.8 to 2 gr/t and lower one - sulfide (primary). Analysis of sample taken from the sulfide (primary) mineralogical-geochemical zone contains 0.31% Cu and 0.27 gr/t Au.

During the flotation of the sulfide ore, copper concentrate and tailings were obtained, which consisted of pyrite and numerous secondary copper minerals such are chalcocite, covellite, malachite, brochantite, alunite, kaolinite and quartz. It was determined that part of Cu and Au goes into the waste products, in which the content is 0.193% and 0.160 gr/t, respectively. Based on this, it is recommended that new approach attempts should be made for flotation study of waste products, using innovative technologies for this purpose.

The two types of concentrates obtained – copper-gold and pyrite (gold-copper content) will go for metallurgical processing. This will increase the economic value of the sulfide ore reserves in the Plavica deposit and efficiency of its development in the future.

Keywords: *Plavica, mineral composition, sulfide ore, flotation, waste.*

APPLICATION OF DEEP EUTECTIC SOLVENTS FOR WATER TREATMENT

Dušan Rakić[1], Aleksandra Cvetanović Kljakić[1], Sanja Panić[1], Igor Antić[1], Jelena Živančev[1], Nataša Đurišić Mladenović[1], Nenad Grba[2], Mirjana Petronijević[1*]

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

*[2] University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, Novi Sad, Serbia, mirjana.petronijevic@uns.ac.rs**

Abstract

To ensure safe drinking water and reduce the harmful impact of wastewater on the environment, pollutants are removed using various water treatment procedures such as oxidation, adsorption, filtration, and biological processes. However, conventional methods only partially remove pesticides, pharmaceuticals, and other organic micropollutants from water. Therefore, researchers focus on improving existing procedures or finding new purification methods. One promising alternative for better efficiency of water treatment is using deep eutectic solvents (DES), as new-generation solvents. The majority of DESs are composed of binary or ternary mixtures that include at least one hydrogen bond donor and one hydrogen bond acceptor. The application of DESs in the extraction of pollutants from water, which has already shown a high percentage of extraction efficiency in laboratory-scale processes, will increase rapidly with expansion to the industrial scale and the development of new, non-toxic hydrophobic DESs.
The WaDES project of the Faculty of Technology Novi Sad aims to investigate the effectiveness of hydrophobic DESs in the process of treating drinking water and wastewater. Through several steps that include the preparation, characterization and selection of DESs and then the treatment of water with selected solvents and determination of their efficiency using modern analytical methods such as ultra-high performance liquid chromatography with mass detection (UHPLC-MS/MS) the obtained results will be indicate whether and to what extent these solvents can be used for the removal of various emergent pollutants and thus pave the way for further research.

Keywords: *Deep eutectic solvents, Extraction, Pollutants removal, Water treatment*

ANALYSIS OF INORGANIC POLLUTION OF THE INDUSTRIAL AREA IN BRANICEVO DISTRICT, THE REPUBLIC OF SERBIA

Gordana Devic[1*], Marija V. Pergal[1], Miodrag Pergal[2]

[1] *University of Belgrade, Institute of Chemistry, Technology and Metallurgy National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia, gordanadevic@gmail.com**
[2] *University of Belgrade, Faculty of Chemistry, Studentski trg 12-16, Belgrade, Serbia*

Abstract

Intensive mining of fossil fuels has caused the exhaustion of nonrenewable natural resources, water, and air pollution, and significant deterioration and degradation of soils. One of the main problems associated with electricity generation from coal combustion is the "energy waste" issue. When analyzing the potentially harmful environmental impact it primarily applies to the heavy metals. Heavy metals accumulate in the soil due to natural lithogenic and pedogenetic processes and anthropogenic factors. The city Kostolac belongs to the group of more polluted cities, especially by heavy metals, as well as air sulphur and nitrogen oxides. This paper aims to determine the impact of Power Plants and Mines Kostolac, on the quality of soil, water and ambient air in the surrounding environment. A multivariate technique has been applied to a data set to determine the contribution of different sources. As for heavy metals such as lead, cadmium and mercury whose concentrations exceeded the limit values in almost all Kostolac soil and water samples, the investigations suggest that apart from ash other sources may be responsible for this contamination, motor vehicle traffic on the roads in the surroundings of the subject area. Also, the investigations have identified agricultural activities as another significant source of contamination, (in the case of Hg) which is due to the use of fertilizers and heavy-metal pesticides that take place in the near farmstead. In the case of arsenic and zinc, only local contamination has been detected. The results of the chemical analysis showed that the surface water in the area near the power plant complex Kostolac is generally of chemical quality suitable for domestic or agricultural use at most of the tested locations. The samples containing slightly higher values than the allowed standards set fall thus into contamination and these samples may not be suitable for human consumption. It was found that the main principal components extracted from the air pollution data were related to traffic activities and coal combustion.

Keywords: *power plant, air pollution, water pollution, soil pollution, heavy metals, multivariate technique.*

COVALENT IMMOBILIZATION OF HORSERADISH PEROXIDASE ON BIO-LINKED MAGNETITE NANOPARTICLES

Mirjana Petronijević[1*], Sanja Panić[1], Aleksandra Cvetanović Kljakić[1], Biljana Lončar[1], Jelena Tanasić[1], Jelena Arsenijević[2], Slavica Ražić[2]

[1] *University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia, mirjana.petronijevic@uns.ac.rs**

[2] *University of Belgrade, Faculty of Pharmacy, Vojvode Stepe 450, Belgrade, Serbia*

Abstract

Enzymes, such as peroxidases, are "green" catalysts used in various environmental processes. Enzymes can be used in free form or immobilized on a solid support such as metal oxides, carbon and composite materials. The appropriate choice of carrier can significantly improve the properties of the enzyme, increase its stability and enable its reuse in multiple cycles.

In this work, the suitability of bio-linked magnetite particles as a solid support for the immobilization of horseradish peroxidase was investigated. The magnetite particles were synthesized by the co-precipitation method in the presence of subcritical water extracts from tangerine peels. The extraction was carried out at 140 °C and autogenous pressure for 10 minutes. The synthesized bio-linked magnetite particles were used as carriers for the immobilization of peroxidase over glutaraldehyde. First, the magnetite particles were modified by mixing with 1% glutaraldehyde for 6 hours to attach functional groups suitable for covalent binding of the enzyme to the surface of the magnetite. Subsequently, the commercial horseradish peroxidase was covalently bound to the modified magnetite particles via aldehyde groups. The resulting biocatalyst showed high enzymatic activity (65 U/g). The biocatalyst retains its high activity in the pH range of 6-8 and in the temperature range 40-60°C. It can be concluded that the synthesized biocatalyst has the potential to be used in various environmental applications.

Keywords: *Biocatalyst, Magnetite particles, Biofunctionalization, Enzyme activity.*

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NONPARAMETRIC STATISTICAL TESTS APPLIED TO WATER QUALITY INDICATORS

Sanja Kovač[1*], Anita Ptiček Siročić[1], Karolina Antolković[1]

[1]*University of Zagreb, Faculty of Geotechnical Engineering, Hallerova aleja 7, Varaždin, Croatia, skovac@gfv.hr**

Abstract

To minimize the risk of infections, it is essential to routinely test for bacteria and harmful contaminants, particularly in areas where water is utilized for drinking or recreational activities. To demonstrate the presence of microbiological indicators (Escherichia coli and intestinal enterococci), water sampling and analysis were conducted at Jarun Lake and Bundek Lake in Zagreb, Croatia, over a span of three years.Sampling and analysis of water are carried out according to the recommendations of competent institutions, and water quality indicators for drinking, bathing, and daily use must be within the permitted limits, which are prescribed by regulations relating to the quality of drinking and everyday water use. The purpose of this study was to identify microbiological indicators of water quality in two distinct lakes and to analyze the results using nonparametric statistical techniques.The hypothesis was examined to determine whether the levels of microbiological indicators collected from various locations in a specific lake are part of a population that has the same median.Nonparametric statistical methods are useful in water quality studies because they don't require assumptions about the underlying distribution of the data. In water quality analysis, data can often be skewed or contain outliers, which makes parametric tests (which assume a normal distribution) unsuitable. Nonparametric methods help to handle these types of data effectively.Some common nonparametric methods used in water quality assessment include: the extended median test and the Kruskal-Wallis test.The Extended Median Test (EMT) is a statistical technique used to compare multiple independent groups to determine whether they come from the same distribution, especially when the data are not normally distributed. It is an extension of the median test,a non-parametric method for comparing two or more groups. The extended median test takes into account the median of each group and is particularly useful when dealing with ordinal or skewed data.The Kruskal-Wallis test is a valuable tool for analyzing water quality data, especially when the data is non-normal or when comparing multiple groups. It helps to determine if there are significant differences in water quality parameters, enabling better water management and treatment decisions.In water quality studies, nonparametric methods are an essential toolkit, especially when dealing with real-world data that may not follow the assumptions required by parametric tests.

Keywords: *water quality,the extended median test, the Kruskal- Wallis test.*

DETERMINATION OF BOD_5, $KMnO_4$ AND TOC IN SURFACE WATERS

Anita Ptiček Siročić[1*], Mladen Šiljeg[1], Dijana Begić Šinjori[2], Dragana Dogančić[1]

[1]*University of Zagreb, Faculty of Geotechnical Engineering, Hallerova aleja 7, Varaždin, Croatia, anitaps@gfv.hr**
[2]*Institute for Public Health Varaždin, Ivana Meštrovića 1/11, Varaždin, Croatia*

Abstract

The onset of industrialization combined with rising living standards and population growth has led to increased consumption, water contamination, and a threat to the already unequal distribution of this most valuable resource. The amount of freshwater consumed worldwide has doubled in the past 50 years, according to UNESCO, and amounts to roughly 3600 cubic kilometers annually, or 9.86 billion cubic meters of fresh water every day. Of this, 70% comes from agriculture (from crop irrigation), 20% comes from industry (from industrial processes, cooling, etc.) and 10% comes from households, drinking water, and sanitation and hygiene services.It was once thought that groundwater could never be contaminated, however this is untrue. The water may still be contaminated or absorb the pollution even when it has been greatly cleaned by evaporation and condensation or by reaching the aquifer through the ground. As a result, all water areas require quality monitoring and analysis.

Rivers, lakes, streams, and other watercourses that are subject to different pollution sources such as wastewater, agricultural practices, and atmospheric precipitation are all considered surface water. Human health, living conditions, and general quality of life are all greatly impacted by water quality, which also supports the socio-economic growth of local communities. Physical-chemical, biological, and microbiological indicators are used to evaluate the quality of water to make sure it is safe for agriculture, industry, and human use. In this work, surface water sampling was carried out at five sites in Varazdin County, Croatia (Lonja, Presečno, Ljubelj, Ljuba voda, and Koruščak) between April 2023 and March 2024. The following indicators were measured: total organic carbon (TOC), potassium permanganate consumption ($KMnO_4$), and biochemical oxygen demand after fivedays (BOD_5). While BOD_5 was noticeably greater in the Koruščak and Ljubelj locations, suggesting the presence of organic materials, the greatest values of TOC were found at the Ljuba voda and Koruščak locations, especially during the summer. Additionally, there was variation in $KMnO_4$ consumption, with higher values at warmer seasons indicating higher levels of organic pollution.

Keywords: *surface waters, water analysis, total organic carbon, potassium permanganate consumption, biochemical oxygen demand after 5 days.*

PRODUCTION OF COMPOST BY BIOCONVERSION OF AGRO-INDUSTRIAL WASTE WITH THE USE OF SELECTED BIOPREPARATIONS

Snežana Dimitrijević[1*], Vladimir Filipović[1], Elmira Saljnikov[1], Svetlana Antić[2], Vera Popović[3], Ivana Matejić[2], Matija Krpović[2]

[1] *University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, Belgrade, Serbia, snezanadimitrijevic12@yahoo.com**
[2]*University of Belgrade, Faculty of Agriculture, Nemanjina 6, Belgrade, Serbia*
[3]*Institute of Field and Vegetable Crops, Maksima Gorkog 30, Novi Sad, Serbia*

Abstract

Accumulation of agro-industrial waste represents problem of environmental pollution, considering that it increases the emission of greenhouse gases. Composting is an environmentally friendly waste management solution based on a circular economy strategy. The bioconversion of agro-industrial waste into the product with added value, such as compost, may reduce the amount of synthetic fertilizers utilized in agriculture. The bioconversion of lignocellulosic material itself is a complex process consisting of pretreatments such as mechanical, chemical or biological. The biodegradation of cellulose consists of the initial action of exo- and endoglucanase enzymes that break down the amorphous and crystalline structure of cellulose. Delignification of lignocellulosic biomass is carried out by extracellular oxidative enzymes, which are mainly produced by fungi that cause wood rot, as well as other types of bacteria. The inoculating lignocellulosic waste materials with specific microbial starters might accelerate the composting. This study developed technology for the production of compost from plant waste using selected organically certified biopreparations based on seaweed extracts, enzyme extracts of entomopathogenic fungi (Beauveria spp., Metarhizium spp., Verticillium spp. - 10%) and a mixture of Bacillus strains. The composting material used, was one of the most abundant agro-industrial wastes, lignocellulosic waste from wheat straw and alfalfa hay. To assess the maturity and quality of the compost, chemical and biological parameters (C/N ratio, pH, electrical conductivity, content of P_2O_5, K_2O, NH_4-N and NO_3-N and phytotoxicity) were monitored during the 40-day monitoring period. According to the results of C/N ratio and NH_4-N and NO_3-N content, the composting process was accelerated at the very beginning in the first 10 days in samples with biopreparations, compared to the control without treatment, which indicates increased microbial activity and accelerated decomposition of organic matter. The Germination index (GI) of the investigated white mustard seeds (Sinapis alba L.), after 40 days of the composting process, is higher by 30% compared to the control, in samples of compost from wheat straw and alfalfa hay with the treatments. The addition of organically certified biopreparations made it possible to reduce the time required for decomposition of plant waste, and the produced compost was acceptable and safe for further use in agriculture, according to all tested chemical and biological parameters and with an improved effect of biofertilization.

Keywords: *composting, wheat straw, alfalfa hay, seaweed extract, enzyme extracts of fungi, Bacillus sp.*

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BIO-OIL FROM AGRICULTURAL WASTE: PYROLYTIC CONVERSION OF TOMATO AND TOBACCO

Jelena Isailović[1*], Emilija Vukićević[2], Gordana Gajica[3], Branimir Jovančićević[2], Jan Schwarzbauer[4], Vesna Antić[5]

*[1]Mining Institute, Batajnički put 2, Belgrade, Serbia, jelena.isailovic@ribeograd.ac.rs**
[2]University of Belgrade, Faculty of Chemistry, Studentski trg 16, Belgrade, Serbia;
[3] University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, Belgrade, Serbia;
[4] RWTH Aachen University, Institute for Organic Biogeochemistry in Geo-Systems, Mies-van-der-Rohe-Straße 1, Aachen, Germany;
[5] Faculty of Agriculture, University of Belgrade, Resavska 58, Zemun, Serbia

Abstract

The growing need to reduce agricultural waste and replace emission from fossil fuels has created a shared research interest. These two areas are complementary, leading to an increased focus on utilizing agricultural waste biomass as an alternative energy source, particularly through the production of liquid and solid biofuels via pyrolysis. Pyrolysis, as a thermochemical process, has gained significant attention for its ability to convert biomass into valuable products, such as bio-oil, which can serve as a renewable energy source, reducing reliance on non-renewable resources. Among the most widely cultivated crops, tomato and tobacco play a significant role in agricultural production. However, the biomass remaining after harvesting, such as stems and leaves, is often left unused, burned, or improperly disposed of, leading to environmental pollution. This biomass, if managed effectively, presents a valuable feedstock for pyrolytic conversion. The pyrolysis of such agricultural waste could provide an opportunity to produce biofuels and other bio-based products, simultaneously reducing waste and generating energy.In this study, the liquid fractions obtained from the pyrolysis of tomato and tobacco biomass were characterized by key parameters such as pH, moisture and ash content, elemental composition, density, viscosity, calorific value, and other relevant analyses. The chemical properties of the bio-oil were carefully analyzed to assess its potential as an alternative fuel. By comparing these parameters with the initial biomass, the potential of the biomass itself as a fuel was evaluated in relation to the bio-oil's characteristics. The study aimed to determine whether pyrolysis could enhance the fuel properties of the biomass, making it more suitable for use in energy generation.The results suggest that the bio-oil exhibits good potential as a high-quality biofuel. Notably, improvements were observed in pH values, a reduction in moisture and oxygen content, and an increase in carbon content and heat value. These changes indicate that the pyrolytic conversion of tomato and tobacco biomass results in bio-oil with improved combustion properties. Additionally, these improvements were further enhanced by the use of catalysts and the addition of materials rich in carbon and hydrogen, such as plastic materials. This demonstrates the potential for optimizing the pyrolysis process to improve the fuel properties of the bio-oil, making it more efficient and suitable for large-scale energy applications.

Keywords: *pyrolysis, agricultural biomass, biofuel production, energy conversion.*

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PYROLYSIS OF AGRICULTURAL RESIDUES AND PLASTIC WASTE: CHARACTERIZATION OF LIQUID FRACTION AND FEEDSTOCK COMPOSITION INFLUENCE

Jelena Isailović[1*], Emilija Vukićević[2], Gordana Gajica[3], Branimir Jovančićević[2], Jan Schwarzbauer[4], Vesna Antić[5]

*[1]Mining Institute, Batajnički put 2, Belgrade, Serbia, jelena.isailovic@ribeograd.ac.rs**
[2]University of Belgrade, Faculty of Chemistry, Studentski trg 16, Belgrade, Serbia;
[3] University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, Belgrade, Serbia;
[4] RWTH Aachen University, Institute for Organic Biogeochemistry in Geo-Systems, Mies-van-der-Rohe-Straße 1, Aachen, Germany;
[5] Faculty of Agriculture, University of Belgrade, Resavska 58, Zemun, Serbia

Abstract

Pyrolysis, as a process of thermal degradation of waste materials in an oxygen-free environment, is an efficient method for converting waste into valuable products. This technology helps reduce the accumulation of agricultural and plastic waste, whose improper disposal poses an environmental problem. At the same time, pyrolysis produces potential energy carriers, whose properties improve when biomass and plastic are pyrolyzed together rather than separately. Corn biomass waste, a widely available agricultural byproduct, and polypropylene, one of the most commonly used plastics, were selected for this study due to their increasing waste generation. Corn biomass is rich in cellulose, hemicellulose, and lignin, while polypropylene consists of long hydrocarbon chains, making their combination particularly interesting for thermochemical conversion. Standard polypropylene, corn biomass waste, and mixture of corn biomass and plastic waste in a mass ratio of 90:10 were pyrolyzed at 500°C in a nitrogen atmosphere. The collected liquid fraction was analyzed, showing a 38% increase in yield for the mixture compared to biomass alone. Additionally, the bio-oil's moisture content decreased by 94%, while its calorific value increased by 19.6%. A GC-MS analysis was performed on the liquid fractions obtained from the pyrolysis of standard polypropylene, corn biomass waste, and the mixture of biomass and plastic waste. The results showed that the characteristic peak ratio of polypropylene increased by 8% in the mixture, while the biomass peak ratio decreased by 7.3%. This suggests that plastic presence promotes the formation of more stable, energy-rich hydrocarbons, while altering biomass decomposition and reducing oxygen-containing compounds. These findings indicate a synergistic effect between biomass and plastic during pyrolysis, enhancing the energy properties of the final product while minimizing undesirable components. Overall, combining plastic and agricultural waste improves the pyrolysis process by increasing liquid yield and optimizing key parameters. This method not only offers an alternative way to manage plastic and agricultural waste but also contributes to the production of higher-quality biofuels. Further research should focus on product quantification and potential catalyst applications to enhance efficiency and selectivity, ensuring a more effective and environmentally friendly approach to waste conversion.

Keywords: *corn, polypropylene, co-pyrolysis, GC-MS analysis, bio-oil, waste valorization.*

Acknowledgement: *This work was supported by the project ''Agricultural residues and plastic waste as a sustainable source of alternative fuels and valuables chemicals.'' (AGRIPLAST), grant No. 01DS21008.*

EXPLORING THE ROLE OF CRUDE LACCASE FROM *C. TROGII* 2SMKN IN THE BIODEGRADATION OF BRILLIANT GREEN DYE: IMPACT OF TEMPERATURE AND pH, PHYTOTOXICITY ASSESSMENT AND ANTIMICROBIAL ACTIVITY

Nevena Ilić[1*], Marija Milić[2], Slađana Davidović[2], Miona Miljković[2], Suzana Dimitrijević-Branković[2], Katarina Mihajlovski[2]

[1]*Innovation Center of Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia, nilic@tmf.bg.ac.rs**
[2]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*

Abstract

Brilliant Green dye is widely used in industries such as paper, textiles, rubber, and plastics, primarily for dyeing wood and silk. However, it poses serious health risks, including toxicity through skin and eye contact, ingestion, and inhalation, which can lead to organ damage if exposure is prolonged. Therefore, the removal of Brilliant Green dye from water is an important environmental concern. This study investigates the potential of crude laccase, extracted from the white rot fungus Coriolopsis trogii 2SMKN, to biodegrade this harmful triphenylmethane dye. The white rot fungus was cultivated on lignocellulosic agro-industrial waste (brewer's spent grain) at 28°C in the dark for six days, producing crude laccase with a total activity of 31.43 IU/g. To test the dye decolorization efficiency, experiments were conducted at temperatures ranging from 20°C to 50°C and pH values between 2.5 and 6.0. The best decolorization rate of 69% was achieved at pH 2.5 and 30°C after 90 min, while only 12% of decolorization was observed at pH 6 and 50°C under the same conditions. After complete dye decolorization, phytotoxicity tests were performed on Triticum aestivum, an agriculturally important crop. The results showed a germination index of 102%, suggesting that the biodegradation products had a phytostimulatory effect. In contrast, test of antimicrobial activity indicated that undegraded dye inhibited the growth of Candida albicans and Lactobacillus rhamnosus by 42% and 30%, respectively, while it had no effect on Saccharomyces cerevisiae. The biodegradation products, however, did not inhibit any of the tested microorganisms. These findings indicate that crude laccases from fungi, when optimal conditions are applied, can effectively decolorize Brilliant Green dye in a relatively short period. Furthermore, the biodegradation products have potential as phytostimulants, offering promising applications in agriculture. This study highlights the utility of fungal enzymes in the bioremediation of harmful dyes, as well as their potential role in promoting sustainable farming practices.

Keywords: *laccase, white rot fungi, lignocellulosic waste, biodegradation, decolorization, phytotoxicity tests*

ASSESSING BISPHENOL A DEGRADATION VIA ELECTRO-FENTON PROCESS: THE ROLE OF LACTIC ACID AS AN INDICATOR

Katarina Stojanović[1*], Marija Ječmenica Dučić[1], Marija Simić[1], Marija Kovačević[1], Dragana Vasić Anićijević[1], Tanja Brdarić[1], Danka Aćimović[1]

*[1]University of Belgrade, "Vinča" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Department of Physical Chemistry, Mike Petrovica Alasa 12-14, Belgrade, Serbia, katarina.stojanovic@vin.bg.ac.rs**

Abstract

Bisphenol A (BPA) is a commonly used industrial chemical in the manufacturing of plastics and resins; however, its endocrine-disrupting properties pose serious health risks to living organisms. By interfering with hormonal balance, BPA can contribute to reproductive and developmental problems. Due to its extensive use, BPA remains prevalent in the environment, highlighting the importance of developing efficient methods for its degradation and monitoring. The electro-Fenton process, utilizing a SnO_2-MWCNT (multi-walled carbon nanotube) anode and a stainless-steel cathode, operated at a current density of 15 mA cm^{-2} in 0.1 M Na_2SO_4 at pH 4 with externally added H_2O_2 (30 mM) and Fe^{2+} (3.66 mM), demonstrated high efficiency in removing BPA from water, achieving complete mineralization into carbon dioxide and water through OH radicals. During the oxidation of BPA via the electro-Fenton process, various intermediates are formed, including hydroxylated BPA derivatives (catechol, dicatechol, quinones) and smaller single-ring molecules such as 4-isopropenylphenol, benzoic acid, 4-hydroxybenzoic acid, 4-hydroxyacetophenone, and hydroxyquinone. These intermediates slowly convert into carboxylic acids, such as lactic acid, and eventually break down into carbon dioxide and water. Based on the obtained results, it can be observed that the concentration of lactic acid steadily increases up to the fourth hour of the electro-Fenton process, at which point it reaches its maximum level. After this peak, the concentration of lactic acid suddenly decreases, suggesting that the degradation process is progressing towards the complete mineralization of BPA. This decline in lactic acid concentration indicates the successful breakdown of intermediate products and the further transformation of these compounds into simpler molecules, ultimately resulting in the complete mineralization of BPA into carbon dioxide and water.

This study highlighted the potential of utilizing lactic acid as an effective indicator of BPA degradation within the electro-Fenton process. The findings suggest that lactic acid can serve as a reliable marker for tracking the progress of the degradation process and provide valuable insights into its overall effectiveness. By monitoring the concentration of lactic acid, it is possible to predict the efficiency of the electro-Fenton process, offering a practical tool for assessing the extent of BPA removal and the success of the mineralization process over time.

Keywords: *bisphenol A, electro-Fenton, OH radicals, wastewater treatment*

PHOTOCATALYTIC DEGRADATION OF AMOXICILLIN ON TITANIUM (IV) OXIDE MODIFIED BY COPPER DEPOSITION

Katarina Stojanović*[1], Marija Kovačević[1], Marija Simić[1], Sanja Živković[1], Danka Aćimović[1], Tanja Brdarić[1], Dragana Vasić Anićijević[1]

*[1]University of Belgrade, "Vinča" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Department of Physical Chemistry, Mike Petrovica Alasa 12-14, Belgrade, Serbia, katarina.stojanovic@vin.bg.ac.rs**

Abstract

Emerging contamination of environmental waters by synthetic organic compounds requires forehand and serious engagement of available scientific and technological resources. The photocatalytic degradation of organic pollutants is a widely investigated and promising methodology, however, it still requires research input to systematize and improve the existing knowledge. TiO_2-based photocatalysts modified by the deposition of noble metals, including Cu, are known for their remarkable ability to split water and generate hydroxyl radicals that can efficiently oxidize organic pollutants in the solution. On the other hand, despite its oxidizing ability to break carbon chains at heteroatomic sites, such generated hydroxyl-radical still does not have enough power to break aromatic structures in conventional laboratory experiments with low power lamps and several hours duration. In the present contribution, the degradation of a widely used antibiotic, amoxicillin on TiO_2 photocatalyst modified by deposition of Cu atoms, has been investigated using UV-Vis spectrometry. The obtained absorbance depletion with added catalyst was 31.5 % in the first 120 minutes of degradation, which was significantly faster than the degradation degree of the amoxicillin solution without catalyst (12.7 %). The observed changes were discussed from a mechanistic point of view by comparing UV-Vis spectra of the degradation process in the presence and absence of the photocatalysts. While the absorbance depletion mainly refers to the efficient breakage of the molecular chains at the heteroatomic sites, the residual absorbance originates from the stable aromatic structures that, besides the efficient generation of hydroxyl radicals, require an additional energetical input to be completely degraded up to the aliphatic structure.

Keywords: *antibiotic, organic pollutants, photocatalysts, TiO_2*

THE IMPORTANCE OF WASTE-TO-ENERGY TECHNOLOGIES IN THE TRANSITION TOWARD A CIRCULAR ECONOMY IN BOSNIA AND HERZEGOVINA

Brankica Gegić[1*], Draženko Bjelić[2] , Dragana Nešković Markić[3], Siniša Dodić[1], Damjan Vučurović[1], Bojana Bajić[1]

*[1]University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Republic of Serbia, brankica11gegic@gmail.com**

[2] University of Banja Luka, Faculty of Technology, Stepe Stepanovica 73, Banja Luka, Bosnia and Herzegovina

[3]Pan-European University "APEIRON", Faculty of Health Sciences, Vojvode Pere Krece 13, Banja Luka, Bosnia and Herzegovina

Abstract

Waste management is a big challenge for Bosnia and Herzegovina (B&H). The population of B&H generated 1.2 million tons of municipal waste in 2023, of which 99% was permanently landfilled. Landfilling waste may negatively affect the health of the population and the environment and also represents a potential loss of a renewable source of energy and other valuable materials that can be obtained from waste. On the other hand, increased energy requirements and the necessary shift toward a circular economy impose the need to pay more attention to waste management and to perceive waste as a resource. B&H, although not a member of the EU, endeavors to meet EU standards in the waste and energy sector and aims to transition to a circular economy. However, during the last 20 years in B&H, in solid waste management, progress has been made in terms of national harmonization with EU legislation, and several sanitary landfills have been constructed, but not much progress has been made beyond that. Also, by signing the Green Agenda for the Western Balkans, B&H has committed to the transition to an economy and society with zero net greenhouse gas emissions by 2050. The key areas to address this challenge are the circular economy and waste management. Waste-to-energy technologies offer environmentally friendly waste management using waste as a renewable energy source. This research provides the current status of waste management in B&H, including available data on waste and a comparison with European Union data, as well as an overview and comparison of available waste-to-energy technologies. Through the review and analysis of waste characteristics and existing waste-to-energy technologies, a combination of anaerobic digestion and fermentation for organic and incineration for inorganic fraction municipal waste could be recommended as a possible solution to sustainable waste management. The recommendations and conclusions in this research could help decision-makers choose waste-to-energy conversion technologies and contribute to the country's transition toward a circular economy.

Keywords: *waste management, municipal waste, waste-to-energy, circular economy.*

UTILIZATION OF CHEMICALLY MODIFIED WALNUT SHELL FOR THE ADSORPTION OF HEAVY METALS FROM AQUEOUS SOLUTIONS

Naji Agilee[1], Tijana Spasojević[2], Milica Delić[1*], Đorđe Orgizović[1], Isabela R. Gria[1], Nevena Prlainović[1], Maja Đolić[1]

[1]*Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade Serbia, mstojkovic@tmf.bg.ac.rs**
[2]*Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*

Abstract

Due to intensive food production, the generation of agricultural waste leads to a significant environmental impact. Nuts, such as hazelnuts, walnuts, and pistachios, are produced in millions of tons annually, given their proven health benefits in human nutrition. However, their consumption implies separation of edible part from the shell, which remains as waste raw material. The shell makes up to 67% of the total weight of walnuts. In this research, the walnut shell was crushed and chemically modified (with 0.5 M citric acid) to investigate the potential of its application as an adsorbent for removing copper and zinc from water. Modified adsorbent material (particles <250 μm) led to the formation of ester bonds between citric acid and the lignocellulosic structure of the shell, which improved its adsorption properties. Characterization of the samples was performed by FTIR analysis, while structural changes were monitored by optical microscopy. Experiments were conducted at an initial metal concentration of 50 mg/L, where the metal removal rate was observed for three hours in a 50 mL solution with the addition of 1 g of adsorbent. The adsorption capacities of Zn^{2+} and Cu^{2+} by walnut shell were 0.082 mg/g and 0.143 mg/g, respectively. The kinetic studies of Zn^{2+} and Cu^{2+} adsorption onto modified walnut shells revealed that the pseudo-second-order (PSO) model best describes the adsorption kinetics of Zn^{2+} ($R^2 = 0.992$). At the same time, for Cu^{2+}, a slightly lower correlation was observed ($R^2 = 0.9423$). The Elovich model, which suggests possible chemisorption, also showed a high correlation, especially for Zn^{2+} ($R^2 = 0.9786$). Results indicated that the kinetics of Zn^{2+} and Cu^{2+} adsorption are initially very fast, then begin to stabilize at approximately 90 minutes of reaction. By the end of the experiment, at a contact time of 180 minutes, Cu^{2+} ion removal reaches approximately 70%, whereas Zn^{2+} adsorption efficiency is slightly lower, around 50%. This trend can be explained by the greater ability of Cu^{2+} ions to form stable complexes with functional groups on the adsorbent surface. Continued research will unveil the extensive possibilities of utilizing walnut shells in water purification processes, by reducing the health risks with heavy metal contamination.

Keywords: *agricultural waste, biosorption, chemical activation, copper, zinc, citric acid.*

HEMP MEMBRANES WITH ANIONIC FUNCTIONALIZATION FOR EFFICIENT REMOVAL OF CATIONIC POLLUTANTS

Ljubica Vasiljević[1], Milena Milošević[2*], Nataša Knežević[3], Miloš Veličković[4], Aleksandar Marinković[4]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34A, Zvornik, Republic of Srpska, Bosnia and Herzegovina*
[2]*University of Belgrade, Institute of Chemistry, Technology and Metallurgy - National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia, milena.milosevic@ihtm.bg.ac.rs**
[3]*University of Belgrade, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Mike Petrovića Alasa 12-14, Belgrade, Serbia*
[4]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*

Abstract

The primary aim of this study is to develop a membrane from treated waste hemp fibers using a dimethyl sulfoxide/tetra-n-butylammonium hydroxide (DMSO/TBAOH) solvent system and citric acid (CA) as an efficient adsorbent for the removal of cations and cationic dyes from water. The bio-renewable membrane (cHM) was prepared at the appropriate molar ratio of functional groups, which provided multiple functionalities for effective removal of cationic pollutants. The formed lignocellulosic cHM adsorbent was characterized in terms of its physicochemical, structural, and morphological properties through point of zero charge (pH_{PZC}), porosity, Scanning Electron Microscopy (SEM), and Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) measurements. Pore size was determined using image analysis and the dry-wet weight method. The effects of pH, initial concentration, temperature, and contact time on adsorption were studied in batch adsorption experiments. The membrane demonstrated high adsorption capacities for cationic pollutants, with values of 398.7 mg g^{-1} for Safranine O (SO), 370.60 mg g^{-1} for Methylene Blue (MB), and 445.4 mg g^{-1} for Crystal Violet (CV), following Langmuir model fitting at 25°C. The adsorption process was found to be endothermic, spontaneous, and efficient, highlighting the membrane's potential for water purification. The kinetic parameters of the adsorption process were fitted to both pseudo-first-order and pseudo-second-order models. The five adsorption-desorption cycles yielded effluent waters rich in desorbed pollutants. Photocatalytic degradation of the desorbed dyes using commercial TiO_2 as a catalyst, along with the chemical precipitation of cations into solid form, resulted in treated water that met current legislative standards. Biodegradability tests of the spent membrane confirmed its environmentally safe disposal after 85% degradation. This work demonstrates the application of green chemistry in transforming waste biomass into a high-performance adsorbent for wastewater treatment, offering an eco-friendly technology for water purification.

Keywords: *hemp fibers, cationic pollutants, sustainable technology, adsorption process, biodegradability*

VALORIZATION OF BURNT IQOS CIGARETTE WASTE INTO HIGH SURFACE AREA BIOCHAR FOR WATER PURIFICATION APPLICATIONS

Hadi Waisi [1, 2]*, Stevan Blagojević[1], Miloš Marinković[1], Marko Milojković[1], Aleksandar Marinković[1], Vladislav Živanić[3], Martina Waisi[2]

[1]*Institute of General and Physical Chemistry, Studentski trg 12/V, Belgrade, Serbia, hadiwaisi@yahoo.com**
[2]*Faculty of Ecology and Environmental Protection, University UNION-Nikola Tesla, Cara Dušana 62-64, Belgrade, Serbia*
[3]*Monteagro d.o.o., Lješka 86, Belgrade, Serbia*

Abstract

This study investigates the valorization of burnt IQOS cigarette waste into biochar and its subsequent activation to enhance structural porosity and surface area for environmental applications. Initiated by pyrolyzing the residual waste at high temperatures, the process yields a carbon-rich biochar, which is then subjected to a chemical activation phase. This phase employs potassium hydroxide (KOH) and steam to introduce a complex porous structure comprised predominantly of micro and mesopores, effectively enlarging the material's surface area. Characterization techniques such as Scanning Electron Microscopy (SEM) and Brunauer-Emmett-Teller (BET) analysis were utilized to ascertain the morphological and surface properties of the activated carbon. The SEM images revealed a highly porous texture, while BET analysis confirmed a substantial increase in surface area, critical for adsorption processes. Further, the activated carbons potential for water purification was evaluated through adsorption tests targeting common aquatic contaminants, including heavy metals and organic compounds. The results demonstrated notable efficiency in removing these pollutants, underlining the active carbon capability as a robust adsorbent. This efficacy is attributed to the increased surface area and the presence of functional groups on the active carbon surface, which interact with the contaminants. Moreover, this research underscores the dual benefit of converting IQOS cigarette waste into a functional material for pollution control, aligning with sustainable waste management and environmental remediation strategies. It not only addresses the disposal issue of cigarette waste but also contributes to the broader context of circular economy practices. The findings encourage further exploration into the applicability of waste-derived active carbon in diverse environmental settings, potentially reducing reliance on conventional adsorbents and fostering innovation in waste recycling technologies.

This pioneering study highlights the innovative use of waste material to address environmental challenges, presenting a scalable opportunity for industrial applications. The implications of such technologies are vast, providing a blueprint for future efforts in environmental management and sustainability.

Keywords: *IQOS Cigarettes, Biochar, Water Purification, Surface Area, Active carbon.*

ENHANCED REMOVAL OF ANTIBIOTICS FROM WASTEWATER USING ACTIVATED HEMP SEED SHELL ACTIVE CARBON: A SUSTAINABLE APPROACH TO WATER PURIFICATION

Hadi Waisi [1, 2]*, Stevan Blagojević[1], Miloš Marinković[1], Marko Milojković[1], Aleksandar Marinković[3], Vladislav Živanić[4], Rade Vesković[5]

[1]*Institute of General and Physical Chemistry, Studentski trg 12/V, Belgrade, Serbia, hadiwaisi@yahoo.com**
[2]*Faculty of Ecology and Environmental Protection, University UNION-Nikola Tesla, Cara Dušana 62-64, Belgrade, Serbia*
[3]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*
[4]*Monteagro d.o.o., Lješka 86, Belgrade, Serbia*
[5]*PR Agrosun 081, Cara Lazara bb, Kruševac, Serbia*

Abstract

This study examines the potential of hemp seed shell active carbon as an innovative solution for removing antibiotics from contaminated water sources. The process involved the thermal conversion of hemp seed shell waste into biochar, followed by its activation to enhance porosity and surface functionality suitable for adsorption applications. The biochar was produced through a controlled pyrolysis process, which optimized the yield and quality of the carbon-rich product. Subsequent chemical activation using phosphoric acid (H_3PO_4) and heat treatment was employed to increase the biochar's surface area and introduce functional groups that facilitate the adsorption of antibiotic molecules. Comprehensive characterization of the activated carbon was conducted using Scanning Electron Microscopy (SEM) to visualize the surface morphology and Brunauer-Emmett-Teller (BET) analysis to quantify the surface area and pore volume. These analyses confirmed the creation of a predominantly microporous structure, which is ideal for the adsorption of small molecular contaminants such as antibiotics. The efficacy of the hemp seed shell active carbon in removing various antibiotics was evaluated through batch adsorption experiments. These experiments targeted common antibiotics found in wastewater, such as tetracycline and sulfonamide. The results showed a significant reduction in antibiotic concentration, demonstrating the active carbon's capability as an effective adsorbent. The transformation of hemp seed shell waste into a functional biochar aligns with sustainable waste management practices and contributes to environmental preservation by addressing the pressing issue of antibiotic contamination in water bodies. This study highlights the role of agricultural waste active carbon in water treatment applications and supports the adoption of green technologies in pollution control.

These findings advocate for broader research into the utilization of different agricultural waste materials for environmental remediation purposes, offering a path towards sustainable management of both agricultural waste and water pollution.

Keywords: *Hemp seed shell, biochar, antibiotics removal, water purification, active carbon.*

ASSESMENT OF THE CURRENT WATER QUALITY STATUS OF THE DRINA RIVER AT SELECTED SITES

Jelena Vuković[1*], Slavko Smiljanić[1]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina, jelenamicic93@gmail.com**

Abstract

To assess the current water quality of the Drina River, water samples were collected from the river and its tributaries at selected locations. A total of 17 samples were taken from various points along the Drina River, including Foča, Višegrad, Bratunac, Zvornik, and Bijeljina, over a period from June 2023 to September 2024. The analysis focused on selected physicochemical parameters and heavy metals. In general, the analyzed samples from the chosen locations showed that the Drina River and its tributaries had predominantly good quality in terms of physicochemical parameters. It was also observed that certain anthropogenic activities have an impact on the water quality of the Drina River. These results may be an indicator of the current impact of certain pollution sources in the Drina River Basin, as well as an introduction to some further studies of the Drina River water quality.

Keywords: *Drina River, surface water quality, physicochemical parameters, heavy metals*

PRELIMINARY ASSESMENT OF THE USE OF RED MUD SLAG FOR PHOSPHATE SORPTION FROM AQUEOUS SOLUTIONS

Jelena Vuković[1*], Slavko N. Smiljanić[1], Duško Kostić[1,2], Srećko Stopić[2], Mitar Perušić[1], Nebojša Vasiljević[1]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina, jelenamicic93@gmail.com**
[2] *RWTH Aachen University, Faculty of Georesources and Materials Engineering, Institute for Metallurgy and Metal Recycling, Intzestr. 1, Aachen, Germany*

Abstract

This paper shows the preliminary results of the investigation of the possibility of the use of red mud slag (RMS) for phosphate sorption from aqueous solution. The red mud slag was obtained from red mud treatment, specifically carbothermal reduction at high temperatures. This process resulted in forming a metallic phase (iron) and slag enriched with other elements. The preliminary analysis of slag is done to investigate its potential for use as a phosphate sorbent in wastewater treatment. The slag is divided into three categories. The two of them are obtained by sieving an original slag sample in the fine fraction and the coarse fraction (the slag residual after sieving). The third sample is the raw slag. After an experiment that included 24-hour shaking of slag and phosphate solution, the results show potential for using red mud slag in phosphate sorption. It is an initial experiment that will be a starting point for further investigation of the sorption characteristics of the red mud slag.

Keywords: *the red mud; carbothermal reduction; the red mud slag; phosphate removal; new sorbents;*

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THE FUTURE OF THE DEVELOPMENT AND USE OF ALTERNATIVE JET FUELS FROM THE ASPECT OF AIR SPACE DECARBONIZATION

Božidarka Arsenović[1*]

[1] *"ORAO" A.D. Šabačkih đaka bb, Bijeljina, Republic of Srpska, Bosnia and Herzegovina, bokijevmejl@gmail.com**

Abstract

In the last decades of the twentieth century, the development and use of sustainable alternative jet fuels emerged as a key factor in reducing the decarbonization of the airspace (reducing aviation-related CO_2 emissions). "Refuel Aviation" initiative promotes the development and use of sustainable aviation fuels. of SAFs (sustainable aviation fuels) for the decarbonization of air traffic, highlighting the obligation of suppliers to increasingly sell sustainable fuels at all airports within the EU. Compared to the CO_2 emission produced during the flight of an airplane with conventional hydrocarbon fuel (kerosene), using alternative jet fuels, it is possible to reduce this emission by up to 80%, depending on the type of raw material used and the method of sustainable fuel production. The International Aviation Transport Association has updated the strategy developed in four stages, the main goal of which is that aircraft have 0% greenhouse gas emissions by 2050. The use of hydrogen as an alternative jet fuel with "zero CO_2 emissions" is considered very interesting, because it can be produced without the generation of CO_2, and in addition, it is present in water in large quantities. On the other hand, for the application of H_2 required is a special airport and transport infrastructure. In addition, today there are a number of challenges and concerns related to the production and implementation of H_2 in the aerospace industry.

The paper gives a brief overview of the future of development and the obligation to use alternative jet fuels from the aspect of airspace decarbonization. In addition, progress and further predictions in aviation were highlighted.

Keywords: *alternative jet fuels, decarbonization, future, development.*

ASSESMENT OF THE OXIDATIVE STATE OF THERMALLY TREATED SUNFLOWER OIL AFTER REGENERATION WITH MOLECULAR SIEVES

Ljubica Vasiljević[1], Sanja Dobrnjac[2], Stevan Blagojević[3], Milenko Aćimović[1]

*[1]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina, ljubica.vasiljevic@tfzv.ues.rs.ba**
[2]Krebs+Kiefer Eastern Europe, Trg Republike Srpske 1, Banja Luka, Bosnia and Herzegovina
[3]Institute of General and Physical Chemistry, Studentski trg 12/V, Belgrade, Serbia

Abstract

Edible oils undergo undesirable changes over time or during thermal treatment due to enzymatic, microbial, and chemical processes, leading to spoilage. In this study, the oxidative state of sunflower oil was assessed by determining the peroxide value (PV), anisidine value (AV), and Totox value (TV) using standard methods. The oil was heated at temperatures ranging from 110 to 190°C for 10 and 30 minutes, also in the presence of molecular sieves (Zeolite 4A, clinoptilolite, and bentonite). When using the synthetic molecular sieve Zeolite 4A, a reduction in the Totox value by 35.72% was observed. When natural molecular sieves were used, a reduction of 33.19% was recorded for clinoptilolite, while for bentonite, the reduction was 31.08%. Both natural and synthetic molecular sieves demonstrated a strong ability to regenerate thermally treated oils.

Keywords: *Sunflower oil, Molecular Sieves, Thermal Treatment, Regeneration, Oxidative state.*

THE COST-EFFECTIVENESS ANALYSIS OF DIFFERENT POWER FACILITIES CONSTRUCTION PROJECTS WITH THE AIM OF DECARBONIZING THE ENERGY SECTOR

Sanja Milivojevic[1*], Milan M. Petrovic[1], Vladimir D. Stevanovic[1], Jovica Riznic[2], Milos Lazarevic[1], Nevena Stevanovic[1]

*[1]University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia; smilivojevic@mas.bg.ac.rs**
[2]Ontario Tech University, Oshawa, Ontario, Canada;

Abstract

In this paper, a comparison of the net present value and the payback period for three different projects of construction and exploitation of plants for the production of electricity with the aim of decarbonizing the energy sector is conducted. The first project is building of the large-scale nuclear power plant with a light-water reactor, the second one is a deployment of nuclear power plant which consists of several identical small modular reactors and the third project is using of renewable energy sources solar and wind power. Given that the sun and wind are intermittent renewable energy sources, it is necessary to take into account the construction of an energy storage facility in the last project.

Keywords: *net present value; payback period; decarbonization.*

POLYURETHANE-BASED NANOCOMPOSITE FOR BIOMEDICAL APPLICATION

Jelena Tanasić[1*], Urszula Klekotka[2], Beata Kalska-Szostko[2], Ivan Krakovsky[3], Tamara Erceg[1], Ivan Ristić[1]

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia, jelenatanasic@uns.ac.rs**
[2]*University of Bialystok, Institute of Chemistry, Bialystok, Poland*
[3]*Charrles University of Prague, Faculty of Mathematics and Physics, Department of Macromolecular Physics, Prague, Czechia*

Abstract

Hydrogels have emerged as promising materials in regenerative medicine due to their biocompatibility and tunable properties. Polyurethane (PU), a versatile polymer, is renowned for its excellent mechanical properties and stability. However, its inherent hydrophobicity limits its application in biomedical fields. To overcome this limitation, polyurethane hydrogels were synthesized by incorporating hydrophilic poly(ethylene oxide) (PEO) segments into the polymer backbone. Additionally, multiwalled carbon nanotubes (MWCNTs) were incorporated as nanofillers to further enhance the mechanical and electrical properties of the hydrogel matrix. The amount of MWCNT was 0.5; 1, 2 and 5 wt%. The synthesis was conducted via a step-growth polymerization reaction between poly[(phenyl isocyanate)-co-formaldehyde] and poly(ethylene oxide) (PEO) with a molecular weight of 10,000 g/mol, using dibutyltin dilaurate as a catalyst. The structure and properties of the resulting hydrogels were characterized using Fourier Transform Infrared Spectroscopy (FTIR), Raman spectroscopy, Differential Scanning Calorimetry (DSC), Scanning Electron Microscopy (SEM), and Transmission Electron Microscopy (TEM). FTIR analysis confirmed the successful formation of polyurethane linkages, while Raman spectroscopy provided evidence of the presence of MWCNTs within the hydrogel matrix. DSC results indicated a decrease in the melting temperature of the PEO segments with increasing MWCNT content, suggesting a disruption of the PEO crystallinity. SEM and TEM images revealed a uniform dispersion of MWCNTs within the hydrogel network and a porous microstructure. MWCNT addition resulted in decreased swelling due to increased crosslinking. These materials hold great potential for applications in various biomedical fields, including tissue engineering and drug delivery.

Keywords: *polyurethane hydrogels, MWCNT, porosity of hydrogels, TEM analyse*

THE INFLUENCE OF TiO_2 NANOPARTICLES ON THERMAL DECOMPOSITION OF POLYURETHANE HARD SEGMENTS

Ivan S. Stefanović[1*], Jasna V. Džunuzović[1], Enis S. Džunuzović[2], Tijana S. Kovač[3], Carla Marega[4]

[1] *University of Belgrade, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic Serbia, Department of Chemistry, Belgrade, Serbia, ivan.stefanovic@ihtm.bg.ac.rs**

[2] *University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia*

[3] *University of Belgrade, Innovation Center, Faculty of Technology and Metallurgy, Belgrade, Serbia*

[4] *University of Padova, Department of Chemical Sciences, Padova, Italy*

Abstract

Polyurethanes are one of the most versatile materials, used in countless commercial applications, mainly because of their outstanding performances. Due to the constant market need to push the boundaries of quality, even with proven good materials, the incorporation of various nanoparticles has become an established method for properties enhancement of polymer-based materials. Therefore, the goal of this work was to investigate the influence of TiO_2 nanoparticles on thermal degradation and thermal degradation kinetics of the hard segments of polyurethane network based on polycaprolactone and aliphatic hyperbranched polyester. For that purpose, two composites were prepared by embedding 1.0 wt.% of unmodified or surface modified TiO_2 nanoparticles into polyurethane matrix. Modified TiO_2 nanoparticles were prepared by their surface modification with lauryl gallate. In order to explore the influence of TiO_2 nanoparticles on thermal degradation kinetics of polyurethane network, thermogravimetric analysis at different heating rates in nitrogen atmosphere was conducted and obtained results were compared with results gathered for pure polyurethane. Model-free iso-conversional Ozawa-Flyyn-Wall method was applied to evaluate kinetic energy of thermal degradation at various degrees of conversion. Furthermore, Coats-Redfern model-fitting method and forty kinetic models were checked to find the one that can adequately describe the degradation mechanism of the hard segments in prepared samples. Obtained results revealed that the presence of unmodified or modified TiO_2 nanoparticles led to the small decrease of the temperature of maximum thermal degradation rate of weak urethane bonds in hard segments. Also, due to the lower crosslinking density, maximum thermal decomposition rate of examined composites was visibly diminished in comparison to the pure polymer. After application of different kinetic model functions through Coats-Redfern equation, it was established that in the case of pure polyurethane network and composite prepared with unmodified TiO_2 nanoparticles, thermal degradation of urethane linkages can be described by power law model, while two-dimensional diffusion is the best fitting kinetic model for describing thermal degradation mechanism of urethane linkages in composite prepared with modified TiO_2 nanoparticles.

Keywords: *polyurethane, TiO_2 nanoparticles, composites, thermal degradation, kinetics.*

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THE INFLUENCE OF TiO_2 NANOPARTICLES ON THERMAL DECOMPOSITION OF POLYURETHANE SOFT SEGMENTS

Ivan S. Stefanović[1*], Jasna V. Džunuzović[1], Enis S. Džunuzović[2], Tijana S. Kovač[3], Carla Marega[4]

*[1] University of Belgrade, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic Serbia, Department of Chemistry, Belgrade, Serbia, ivan.stefanovic@ihtm.bg.ac.rs**
[2] University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia
[3] University of Belgrade, Innovation Center, Faculty of Technology and Metallurgy, Belgrade, Serbia
[4] University of Padova, Department of Chemical Sciences, Padova, Italy

Abstract

Testing the behavior of polymeric materials during heating, especially when it comes to materials that have wide practical application and therefore large commercial importance, such as polyurethanes, is essential. Results obtained by investigating thermal stability and thermal decomposition of polymers, including kinetic modeling, can help to understand the mechanism of thermal degradation reaction and also can be very helpful in an attempt to predict and roughly evaluate lifetime of polymeric materials. In relation to that, the aim of this work was to examine the effect of unmodified and surface modified TiO_2 nanoparticles on thermal degradation and thermal degradation kinetics of the soft segments of polyurethane network based on polycaprolactone and aliphatic hyperbranched polyester. Surface modification of TiO_2 nanoparticles was performed using gallic acid ester having C12 long alkyl chain (lauryl gallate). Results obtained by thermogravimetric analysis performed at different heating rates in nitrogen atmosphere for pure polyurethane and composites prepared by incorporation of 1.0 wt.% of unmodified or surface modified TiO_2 nanoparticles into polyurethane matrix were compared. It was established that thermal decomposition of soft segments, i.e. polycaprolactone, is shifted to higher temperatures for composites, and this shift is more pronounced for the sample prepared with modified TiO_2 nanoparticles. Furthermore, using values of the activation energy of thermal degradation calculated by model-free Ozawa-Flyyn-Wall method, together with Coats-Redfern model-fitting method and numerous kinetic models, the degradation mechanism of soft segments was investigated. It has been shown that the best fitting kinetic model which can be applied to describe thermal degradation mechanism of the soft polycaprolactone segments in the prepared samples is the second (for pure polyurethane), i.e. the third (for composites) reaction order kinetic model.

Keywords: *polyurethane, TiO_2 nanoparticles, composites, thermal degradation, kinetics.*

Acknowledgments: *This work was supported by the Ministry of Science, Technological Development and Innovation of Republic of Serbia (Grant No. 451-03-66/2024-03/200026 and 451-03-65/2024-03/200135) and by the Science Fund of the Republic of Serbia, Program PRISMA, Grant No. 5354, Multifunctional visible-light-responsive inorganic-organic hybrids for efficient hydrogen production and disinfection - HYDIS.*

RADICAL SCAVENGING ACTIVITY OF SILYMARIN ENCAPSULATED IN LIPOSOMAL VESICLES: IMPACT OF UV IRRADIATION AND LYOPHILIZATION

Amjed Karkad[1,2], Milena Milošević[3], Andrea Pirković[4], Aleksandar Marinković[2], Aleksandra Jovanović[4*]

[1]Elmergib University, Faculty of Medical Technology, Msallata, Libya
[2] University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia
[3] University of Belgrade, National Institute of the Republic of Serbia, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia
*[4] University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia, ajovanovic@inep.co.rs**

Abstract

Silymarin exhibits plenty of bioactivities that can promote human health and well-being. Nevertheless, silymarin is poorly soluble and possesses lower bioavailability, thus, its application is quite limited. Liposomes can increase the stability of encapsulated sensitive compounds and the bioavailability of poorly hydrosoluble components. Concerning potential implementation in various industries, liposomal sterilization, such as UV irradiation, remains a real challenge because of the carriers' particular sensitivity and physicochemical alterations. Lyophilization provides dried products with active compounds that are stable over a long period, due to the prevention of hydrolytic and oxidative degradation which can occur in the water surrounding. However, the lyophilization process can result in significant modifications of the liposomes, thus its effect should be examined as well. The radical scavenging activity of silymarin-loaded liposomes after different technological processes (UV irradiation and lyophilization) was investigated using DPPH and ABTS assays. In the DPPH method, the antioxidant capacity of pure silymarin was 84.03%, while it was lower after the encapsulation in liposomes; 81.63% after the formulation, 81.15% after UV irradiation, and 79.85% after lyophilization. The anti-ABTS potential was 3.04 µmol Trolox equivalent (TE)/mL for silymarin, 1.68 µmol TE/mL after the liposome preparation, 1.52 µmol TE/mL after UV irradiation, and 2.02 µmol TE/mL after lyophilization. UV irradiation did not cause significant changes in the antioxidant potential of liposomes, while ABTS scavenging activity was higher after lyophilization. Considering that the two used antioxidant assays are based on different reactions, the obtained data provide good insight into the overall antioxidant activity of silymarin-loaded liposomes.

Keywords: *antioxidants, liposomes, silymarin, lyophilization, UV irradiation.*

UV IRRADIATION INFLUENCE ON FUMITORY EXTRACT-LOADED LIPOSOMES

Rabiea Ashowen Ahmoda[1], Andrea Pirković[2], Milena Milošević[3], Aleksandar Marinković[1], Aleksandra Jovanović[2*]

[1] *University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*
[2] *University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia, ajovanovic@inep.co.rs**
[3] *University of Belgrade, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia*

Abstract

Fumaria officinalis L. is a scrambling annual plant, disturbed and cultivated throughout Europe, and represents a component of various phytotherapeutic formulations in the European ethnobotany used in hepatobiliary dysfunction, illnesses of gastrointestinal and urogenital tracts, cancer, rheumatism, high blood pressure, and skin disorders. The aim of the present study was the characterization of fumitory extract-loaded liposomal vesicles after UV irradiation via the determination of encapsulation efficiency, size, polydispersity index (PDI), zeta potential, mobility, and conductivity. The encapsulation efficiency was the same before and after UV irradiation (>69%). Particle size and PDI of the UV-irradiated liposomes with fumitory extract were 294.2±4.1 nm and 0.387±0.011, respectively. The zeta potential after UV irradiation was -5.51±0.4 mV. Mobility and conductivity of the obtained liposomal particles were -0.429±0.012 μmcm/Vs and 0.468±0.005 mS/cm, respectively. The results indicate the existence of nanoparticles and a non-uniform system with very low values of zeta potential and mobility. A negative zeta potential value is related to the organization of phospholipids, whereas a low value suggests that the liposomal suspension is not electrostatically stabilized. The beneficial effects of bioactive principles from F. officinalis on human health highlight the application of liposomes as a carrier for its extracts and their potential implementation in various formulations. Since UV irradiation did not cause significant changes in all mentioned parameters of fumitory extract-loaded liposomes, it can be employed as a sterilization step in the preparation of liposomes for potential application in foods, functional foods, dermo-cosmetics, and pharmaceutics.

Keywords: *Fumaria officinalis, liposomes, particle size, UV irradiation, zeta potential.*

STORAGE STABILITY OF THE LIPOSOMAL SYSTEM WITH ENCAPSULATED *VACCINIUM MYRTILLUS* EXTRACT

Amjed Karkad[1,2], Muna Rajab Elferjane[2,3], Milena Milošević[4], Andrea Pirković[5], Diana Lupulović[5], Aleksandar Marinković[2], Aleksandra Jovanović[5*]

[1]Elmergib University, Faculty of Medical Technology, Msallata, Libya
[2] University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia
[3] University of Misurata, Faculty of Nursing and Health Sciences, Alshowahda Park, 3rd Ring Road, Misurata, Libya
[4] University of Belgrade, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia
*[5] University of Belgrade, Institute for the Application of Nuclear Energy INEP, Banatska 31b, Belgrade, Serbia, ajovanovic@inep.co.rs**

Abstract

Vaccinium myrtillus fruits and leaves show significant economic importance due to their application in food, functional food, pharmaceutical, cosmetic, and healthcare products. Bilberry leaves contain valuable components, such as phenolic acids, flavonoids, procyanidins, anthocyanins, fatty acids, and dietary fibers. The mentioned compounds possess various biological potentials, including antioxidant, anti-inflammatory, antimicrobial, regenerative, astringent, lipid-lowering, and anti-diabetic properties. With the aim of improving storage stability, biodistribution, and bioavailability, as well as providing controlled release of bioactive compounds, V. myrtillus extract was encapsulated in the liposomal vesicles, and their storage stability and stability after UV irradiation were monitored. Vesicle size, polydispersity index (PDI), and zeta potential were determined in the 60-day storage study at 4°C. The liposome size varied in a narrow range. PDI values were between 0.294 and 0.338 (for the non-treated sample) and 0.249 and 0.437 (for the UV-irradiated sample). The zeta potential was -5.02 mV on the 1st day and -9.16 mV on the 60th day for non-treated liposomes, while for UV-irritated, the zeta potential amounted to -3.93 mV on the 1st day and -8.22 mV on the 60th day. In both types of the sample, there was no significant change in the vesicle size during storage, while the zeta potential (absolute value) increased. Additionally, the PDI value increased in the UV-irradiated liposomes. The beneficial effects of bioactive principles from bilberry leaf on human health highlight the application of liposomes as a carrier for its extract and their potential implementation in food, functional food, pharmaceutical, and cosmetic formulations.

Keywords: *bilberry, liposomal particles, polydispersity index, storage stability, zeta potential.*

ELION TECHNIQUES FOR BIOLOGICAL AND NONBIOLOGICAL MATERIALS MODIFICATION IN THE CONTINOUS AND ULTRAFAST COHERENT SOURCES ERA

Milesa Srećković[1*], Milorad Tomić[2], Snežana Stojičić[3], Svetlana Pelemiš[2], Sanja Jevtić[4], Aleksandar Bugarinović[5], Zoran Latinović[1]

*[1] University of Belgrade, Faculty of Electrical Engineering, Bulevar kralja Aleksandra 73, Belgrade, Serbia, esreckov@etf.bg.ac.rs**
[2] University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Bosnia and Herzegovina
[3]Ministry of Internal Affairs of the Republic of Serbia, Kneza Miloša 101, Belgrade, Serbia
[4]Academy of Technical and Art Applied Studies Belgrade, Zdravka Čelara 16, Belgrade, Serbia
[5]KBV DATACOM, Vladimira Popovića 6, Belgrade, Serbia

Abstract

Modern material modifications using elion techniques, with an emphasis on stimulated radiationin UV/VIS. IR spectra incorporate vast number of activities. One direction of the development of these effects is of speciall interest in the biological sphere, where Elion techniques are used in modulation tasks, and in the strict modern metrology approach for the quantification of the sample changes. The headlines are long time present for wheat fields (Laser goes to field). In parallel experiments with nuclear radiation and spontaneous radiation sources were conducted (electromagnetic X and gamma rays, and proton, neutron particles, nuclear isotopes) are shown in macroscopic statistical results. Novelty in this field is the introduction of hyperfast processes and their influence on plant seeds, beeing sown, where the changes are monitored in shorterm and longterms intervals. The paper will analyse results obtained at present time with irradiation by some of the groups of Elion techiques, characteristic trends and results. In particular, the qualitative and quantitative monitoring of the author's selected experiments will be analyzed, simulated and depicted.During the analysis, attention will be focused to vastly spread plant species, and medicinal herbs, where it is especially important to increase the amount of medicinal substances by means of elion techniques, but also on planned malformations.

Keywords: *materials, laser, Elion techniques.*

IMPACT OF MIDDLE BLOCK COMPOSITION ON THE THERMAL BEHAVIOUR OF POLY(L-LACTIDE)-BASED TRIBLOCK COPOLYMERS

Ivan Ristić[1*], Marija Krstić[1], Suzana Cakić[2], Jelena Tanasić[1], Nina Jokić[1], Ljubiša Nikolić[2], Vladan Mićić[3]

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia, ivan.ristic@uns.ac.rs**

[2]*University of Niš, Faculty of Technology, Bulevar oslobođenja 126, Leskovac, Serbia*

[3]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Bosnia and Herzegovina*

Abstract

Poly(L-lactide) (PLLA), a biodegradable polymer with properties comparable to conventional plastics, is limited by its inherent brittleness and thermal instability. This study explores the enhancement of PLLA properties through the synthesis of ABA-type block copolymers with distinct soft middle blocks—polyester poly(methylricinoleate) (PMR) and polyether poly(1,3-propane diol) (PPD). As a first two types of soft-middle blocks, poly(methylricinoleate) and poly(1,3-propane diol) with dihydroxyl end groups were synthesized. After that, two series of novel biodegradable triblock copolymers, PLLA-b-PMR-b-PLLA and PLLA-b-PPD-b-PLLA, were obtained. By systematically comparing these two systems using FTIR, DSC, and TG, this work investigates how the topology and structure of the middle block influence the thermal, and phase behavior of the resulting materials. FTIR spectroscopy analysis confirmed presumed structure of block copolymer. In addition, the block structure was confirmed by the existence of two separate glass transition temperatures for middle blocks and PLLA. The type of middle blocks influenced crystallization and melting of PLLA segments, which are completely hindered in PPD based block copolymers. PMR based triblock copolyester, due to the high degree of phase separation, shows a clear trend of increasing T_g value of PLLA segments with increasing its molar mass. Using TG analysis of the pure segments it was confirmed that the beginning of segment decomposition in triblock polymer significantly shifted to higher temperatures compared to pure blocks, as a consequence of phase separation of blocks, with PMR-based systems showing the most pronounced increase in decomposition onset temperatures. The topology of the copolymer components and the structure of the middle soft block were crucial for adjusting the thermal characteritics of synthetized block copolymers. The results reveal that the immiscibility between the hard PLLA and soft middle segments creates phase-separated structures, leading to a significant shift in thermal decomposition temperatures. These findings underscore the importance of middle block composition in tuning the thermal properties of biodegradable polymers and offer a pathway for designing high-performance, sustainable polymers for advanced applications.

Keywords: *biobased polymers, polylactide, segmented block copolymer, thermal properties.*

ADVANCES IN SYNTHESIS OF NANOSIZED OXIDIC POWDERS USING ULTRASONIC SPRAY PYROLYSIS

Duško Kostić[1,2*], Srećko Stopić[1], Mitar Perušić[2], Vladimir Damjanović[3], Radislav Filipović[2,3], Bernd Friedrich[1]

*[1]IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Aachen, Germany, dkostic@ime-aachen.de**
[2] University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina
[3]Alumina d.o.o., Karakaj, Zvornik, Bosnia and Herzegovina

Abstract

The synthesis of oxide nanopowders through ultrasonic spray pyrolysis (USP) represents an innovative and sustainable approach for producing high-purity, spherical particles with advanced material applications. Advances in USP-synthesis are performed using continuous transport of aerosol from an ultrasonic generator to the furnace and collection of nanopowders via electrostatic precipitator. This research focuses on the ultrasonic spray pyrolysis of titanium and aluminum nitrate solutions derived from aluminum industry byproducts, emphasizing resource valorization and waste minimization. Titanium oxysulfate was synthesized by leaching of the slag (from reduction of red mud) with sulfuric acid in an oxidizing, high-pressure environment, followed by purification of the solution to ensure chemical stability and purity. This purified solution was then subjected to USP under a hydrogen reduction atmosphere, producing spherical titanium dioxide (TiO_2) nanopowders. The hydrogen reduction process facilitated precise control over the morphology and crystallinity of the TiO_2 nanoparticles, making them suitable for applications such as photocatalysis, pigments, and advanced coatings. In parallel, aluminum nitrate [$Al(NO_3)_3$] was prepared by leaching aluminum hydroxide oxide (AlOOH) with hydrochloric acid to generate aluminum chloride ($AlCl_3$), followed by the addition of nitric acid to convert the chloride into a nitrate solution. This aluminum nitrate solution underwent ultrasonic spray pyrolysis, leading to the formation of highly uniform, spherical alumina (Al_2O_3) nanopowders with excellent purity and consistent size distribution. The alumina powders possess versatile properties, making them ideal for applications in ceramics, catalysts, and high-temperature materials. This study showcases the potential of ultrasonic spray pyrolysis as an efficient and scalable method for synthesizing oxide nanopowders from industrially derived precursors. By utilizing byproducts of the aluminum industry, the process highlights the dual benefits of producing high-performance materials and promoting environmental sustainability. The resulting nanopowders with their controlled properties and diverse applicability has been significant advancements in oxide powder synthesis.

Keywords: *alumina, leaching, titanium dioxide, nanopowder reduction, ultrasonic spray pyrolysis.*

THE INFLUENCE OF DOUBLE LAYERED OXIDE (Fe/Al LDO) NANOPARTICLES ON THE PROPERTIES OF COPPER-BASED COMPOSITE COATINGS

Samah Sasi Maoloud Mohamed[1], Nebojša D. Nikolić[2], Marija M. Vuksanović[3], Rastko Vasilić[4], Dana G. Vasiljević-Radović[2], Aleksandar D. Marinković[1], Ivana O. Mladenović[2*]

[1]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia

*[2]University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12 Belgrade, Serbia, ivana.mladenovic@ihtm.bg.ac.rs**

[3]University of Belgrade, Department of Chemical Dynamics, and Permanent Education, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Mike Petrovića Alasa, Belgrade, Serbia

[4] University of Belgrade, Faculty of Physics, Studentski Trg 12-16, Belgrade, Serbia

Abstract

In this study, the co-electrodeposition (CED) method was utilized to produce copper metal matrix composite coatings (Cu-MMC) using lab-made sulfate electrolyte and lab-made synthesized nanoparticles of ferrite-aluminum layered double oxide (Fe/Al LDO) as reinforcement. Copper coatings and co-electrodeposited Cu-MMC coatings with Fe/Al LDO nanoparticles had thicknesses of 5, 10, 20, and 50 μm. The Fe/Al LDO nanoparticles were produced using the co-precipitation process from aqueous solutions, which are used for the synthesis of Fe/Al LDH (hydroxide form). After LDH synthesis, the calcination method (600°C in the oven for 3h) was applied for synthesis in their oxide form. The Field Emission Scanning Electron Microscopy (FE-SEM), an Atomic Force Microscopy (AFM), and an X-ray powder diffractometer (XRD) were used for the investigation of the morphology, topography, roughness, and texture of Cu and Cu-MMC coatings. The Vickers microindentation hardness tester and static sessile drop technique were used to analyse microhardness and wettability features of the Cu coatings that were electrodeposited galvanostatically both with and without a low concentration (0.3 wt. %) of Fe/Al LDO nanoparticles on brass sheets. Since all Cu coatings were microcrystalline and fine-grained (with a preferred orientation of (220)), the degree of the roughness and preferred orientation increased with coating thickness. Fe/Al LDO nanoparticles were uniformly distributed throughout the coating's interior, according to the cross-section study of coatings electrodeposited with these particles. Cu coatings electrodeposited with Fe/Al LDO nanoparticles had a significantly higher hardness than the coating made from the reinforcement-free electrolyte, according to a hardness analysis of the coatings conducted using the Chicot-Lesage (C-L) composite hardness model. The wettability properties of the Cu coatings were also altered by the addition of Fe/Al LDO to the electrolyte. The hydrophilic character of the Cu coating derived from the reinforcement-free electrolyte was replaced by hydrophobic coatings resulting from the addition of Fe/Al LDO nanoparticles. The Fe/Al LDO nanoparticles were very stable in acidic sulfate electrolyte and as such they are an excellent choice for reinforcing thin metal coatings deposited electrochemically.

Keywords: *Fe/Al layered double oxide, copper coatings, roughness, texture, hardness, wettability.*

COPPER MATRIX COMPOSITE LAYERS CO-ELECTRODEPOSITED FROM SULFATE BATH WITH ALUMINA NANOPARTICLES SYNTHETIZED BY SOL-GEL TECHNIQUE

Samah Sasi Maoloud Mohamed[1], Marija M. Vuksanović[2], Dana G. Vasiljević-Radović[3], Željko Radovanović[4], Radmila M. Jančić Heinneman[1], Aleksandar D. Marinković[1], Ivana O. Mladenović[3*]

[1]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia*
[2]*University of Belgrade, Department of Chemical Dynamics, and Permanent Education, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Mike Petrovića Alasa, Belgrade, Serbia*
[3]*University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, Belgrade, Serbia, ivana.mladenovic@ihtm.bg.ac.rs**
[4] *Innovation Centerre of Faculty of Technology and Metallurgy LTD., Karnegijeva 4, Belgrade, Serbia*

Abstract

The alumina nanoparticles (Al_2O_3) were synthesized using the sol-gel technique from an inorganic solution. The obtained nanoparticles had a microstructure of corundum after calcination at 1000°C. For characterization of alumina nanoparticles, use the FE-SEM/EDS method with mapping software, XRD, and TEM. The α-Al_2O_3 phase was detected with an average particle size of 100 nm. After synthesis of Al_2O_3 nanoparticles, the various concentrations of particles were added in lab-made sulfate electrolyte (1.0, 3.0, and 5.0 wt. %). The direct current (DC) galvanostatic regime with constant current density (50 mA·cm-2) was chosen for co-electrodeposited free Cu layers and an alumina particles in-corporated copper composite layers. Three layer thicknesses were designed: 2, 22, and 52 μm with the aim of investigating the influence of layer thickness on the change in mechanical (hardness and adhesion), structural (grain size, crystallinity), topography (roughness), and hydrophilic/hydrophobic (water contact angle) properties of the layers. The optimal layer thickness and concentrations of alumina particles were done. After microindentation testing, increased microhardness values were observed: 9.96 % (1.0 wt. % of α-Al_2O_3), 134.1 % (3.0 wt. % of α-Al_2O_3), and 61.9 % (5.0 wt. % of α-Al_2O_3) compared with the Cu layer without alumina reinforcement. The adhesion values of Cu and Cu-Al2O3 layers were evaluated according to micro indentation adhesion method and Chen-Gao mathematical model which used for calculated the critical reduced depth. The best adhesion has a layer of Cu-Al_2O_3 with 1.0 wt. % of alumina particles and 52 μm thickness. The surface roughness parameter of the alumina-reinforced copper layer increased from 3 to 7 times compared to Cu-free layers, according to AFM analysis. By incorporating 3.0 and 5.0 wt. % of α-Al_2O_3, the composite film becomes harder than the brass substrate (HV = 144), and layer hardnesses were 102 HV (1.0 wt. % of α-Al_2O_3), 217 HV (3.0 wt. % of α-Al_2O_3), and 150 HV (5.0 wt. % of α-Al_2O_3) for an optimal layer thickness of 22 μm. The oscillation of microhardness values is consistent with the change in copper grain size. Based on image analysis, the grain size of the copper layer is in the range of 0.7 to 2.5 μm, and for the layer with particles, it is in the range of 0.9 to 4.5 μm. Grain size of copper layes have the same trend as the roughness, shows an increasing character with increasing layer thickness and with the incorporation of alumina particles. Wettability of the layer is better when α-Al_2O_3 nanoparticles are incorporated in the layer, and the measured water contact angles ranged from 66.57 ± 0.94° to 81.42 ± 1.10°.

Keywords: *sol-gel, alumina, copper matrix composite, microhardness, adhesion.*

GREEN ALTERNATIVE FOR WOOLEN KNITWEAR DYEING WITH WALNUT HULLS USING DEEP EUTECTIC SOLVENT

Milena Nikodijević[1*], Slađana Kapuši[1], Dragan Troter[1], Sandra Konstantinović[1]

[1]*University of Niš, Faculty of Technology, Bulevar oslobođenja 124, Leskovac, Serbia, nikmilena94@gmail.com**

Abstract

About 20% of the world's clean water pollution is considered to be caused by the textile industry's dyeing and finishing processes. Therefore, it is necessary to develop an environmentally acceptable but also economically profitable dyeing process. Wool is a natural fiber with a high content of keratin (about 80%) and sulfur and has specific properties such as fire resistance, elasticity, hygroscopicity, low thermal conductivity, and antistatic. Because of these characteristics, wool is often used in the production of high-quality textile products. Although wool is dyed with acid, metal complex, and sulfur dyes, in recent years there has been a growing interest in the use of natural dyes, which offer a more environmentally sustainable alternative to synthetic dyes. In this paper, 100% woolen knitwear made of extra fine merino wool was used, with a mass per unit area of 434 g/m² and fineness of 48×2 tex. The dyeing process was carried out in a deep eutectic solvent consisting of urea, betaine hydrochloride, and glycerol (molar ratio 1:1:1) with walnut hulls powder. The procedure was performed at 80 °C for 60 minutes with a bath ratio of 1:50 at different dye concentrations (10–50%) and pH 4. Dyeing efficiency was analyzed using K/S and CIELab parameters. The results of the CIELab parameters showed that the woolen knitwear was successfully dyed in the deep eutectic solvent using the natural walnut hulls. The highest differences of CIELab parameters between the raw and dyed samples were observed at 50% dye concentration (ΔL -23.18, Δa*=5.76, Δb*=2.69, ΔC*=3.55, ΔE*=24.04). Obtained results for CIELab were confirmed by K/S values obtained for all dyed samples. The CIELab and K/S values showed that the dyeing of woolen knitwear in the deep eutectic solvent with natural walnut hulls can be a good alternative to the standard dyeing process, considering environmental and techno-economic aspects.*

Keywords: *wool, knitwear, dyeing, natural dye, deep eutectic solvent.*

PHYSICAL-MECHANICAL AND THERMAL PROPERTIES OF POLYESTER FABRIC DYED IN DEEP EUTECTIC SOLVENT WITH DISPERSE DYE

Milena Nikodijević[1*], Ana Stojković[2], Ivan Krstić[2], Dragan Troter[1], Sandra Konstantinović[1]

[1]*University of Niš, Faculty of Technology, Bulevar oslobođenja 124, Leskovac, Serbia, nikmilena94@gmail.com**
[2]*University of Niš, Faculty of Occupational Safety, Čarnojevića 10a, Niš, Serbia*

Abstract

Dyeing of polyester fabrics is usually done at high temperatures with the use of carriers and dispersants, which are often toxic. Standard dyeing methods not only consume large amounts of energy but also contribute significantly to environmental pollution. In this work, standard and alternative methods of dyeing polyester fabric with Disperse Red 60 were developed. 100% unprocessed polyester fabric with a mass per unit area of 75 $g \cdot m^{-2}$ was used. Standard dyeing was performed in the presence of a carrier and dispersant, while alternative dyeing is in the presence of a deep eutectic solvent based on betaine hydrochloride as a dyeing medium. Both standard and alternative dyeing processes were performed at different dye concentrations (1-5%) and pH 4. The bath ratio for the standard method was 1:50, and for the alternative method was 70:30 (deep eutectic solvent/distilled water). Standard dyeing was done at 100 °C for 60 minutes, while alternative dyeing was performed at 80 °C for 30 minutes. The samples were analyzed using physical-mechanical characteristics and thermogravimetric (TGA) analysis. The values of tensile strength and elongation at break are similar for all samples (raw and dyed samples), which means that the mechanical structure was unaffected. Based on the TGA analysis, it can be concluded that the degradation processes took place in three phases, starting with (between 100 °C and 200 °C, 200 °C and 300 °C, and at 400 °C). It was observed that the thermal stability of undyed polyester is lower compared to polyester dyed by the standard method and in deep eutectic solvent. At a temperature of about 400 °C, mass residues of 81.519% for undyed polyester, 80.259% for polyester dyed by the standard method and 74.673% for dyed polyester in deep eutectic solvent are detected. These results indicate that deep eutectic solvent-dyed polyester is the most thermally stable.

Keywords: *polyester, deep eutectic solvent, dyeing, betaine hydrochloride.*

SYNTHESIS AND CHARACTERISATION OF CONDUCTIVE POLYANILINE BASED BIOCOMPOSITES FOR SENSOR APPLICATIONS

Ivan Ristić[1*], Marija Krstić[1], Darko Manjenčić[2], Senka Popović[1]

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia, ivan.ristic@uns.ac.rs**

[2]*Academy Kruševac, Department of Technical and Technological Studies, Kosančićeva 36, Kruševac, Serbia*

Abstract

Conductive polymer composites offer innovative solutions for real-time food quality monitoring by enabling direct interaction with spoilage indicators. In this study, polyaniline (PANI) doped with trifluoromethanesulfonic acid (TFMS) was synthesized via oxidative polymerization and incorporated into biopolymer matrices—polylactide (PLA) and polyurethane (PU)—to develop conductive sensing materials. Composites were prepared with PANI loadings of 10%, 20%, 25%, and 30% by weight of the biopolymer to investigate the effect of filler content on electrical and thermal properties. The chemical structure of PANI and its composites was confirmed through Fourier-transform infrared spectroscopy (FTIR), while conductivity was evaluated via the four-point probe method. Thermal stability was assessed using thermogravimetric analysis (TGA), revealing that the incorporation of PANI significantly improved the degradation resistance of the biopolymer matrices. Conductivity testing demonstrated that a minimum PANI content of 20 wt% was required to achieve conductive properties in both matrices, while further increases in PANI concentration leading to enhanced electrical performance. By selecting the appropriate polymer matrix and optimizing PANI content, conductive composites with tailored electrical and thermal, properties can be designed to meet specific application needs. The developed composites exhibited a tunable response to food spoilage gases, undergoing a distinct colorimetric transition from green to blue due to redox state shifts in PANI induced by exposure to gases like NO_2. This real-time sensing mechanism, combined with the biodegradable nature of PLA and PU, offers a sustainable and effective strategy for intelligent food packaging. The results highlight the potential of PANI-based biocomposites as multifunctional materials that enhance food safety, extend shelf life, and contribute to reducing food waste in perishable goods.

Keywords: *conductive composites, polyaniline, intelligent food packaging, polymeric sensors*

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THE INFLUENCE OF Co OXIDE-DOPPED CeO_2/Y_2O_3 CORE ON THE OXYGEN EVOLUTION REACTION ACTIVITY OF IrO_2 SHELL

Katarina Đ. Božić[1,2*], Marija D. Mihailović[1], Marijana R. Pantović Pavlović[1,2], Maja R. Stevanović[3], Miroslav M. Pavlović[1,2], Enisa S. Selimović[4], Vladimir V. Panić[1,2,4]

*[1]University of Belgrade - Institute of Chemistry, Technology and Metallurgy - National Institute of the Republic of Serbia, Department of Electrochemistry, Njegoševa 12, Belgrade, Serbia, katarina.bozic@ihtm.bg.ac.rs**
[2]Center of Excellence in Environmental Chemistry and Engineering, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, Belgrade, Serbia
[3]University of Belgrade, Innovation Center of Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia
[4]State University of Novi Pazar,Vuka Karadžića bb, Novi Pazar, Serbia

Abstract

The consecutive microwave-assisted hydrothermal shelling combined with aerosol-assisted calcination was applied as a synthesis route for IrO_2-shelled CoCeY oxide core composites, designed as potential high-efficiency catalysts for the oxygen evolution reaction (OER) with a reduced iridium content. The search for such efficient OER catalysts is of great significance in advancing metal-air rechargeable batteries and hydrogen production via water electrolysis, where minimizing the use of costly noble metals remains a critical challenge. CoCeY oxide supports were synthesized using a one-step ultrasonic spray pyrolysis (USP) process, in which precursor aqueous solutions of $CeCl_3$, $Y(NO_3)_3$, and $Co(NO_3)_2$ were mixed in mole ratios of Ce:Y:Co = 8:2:5 and Ce:Y:Co = 2:8:5. The USP process was carried out under precisely controlled conditions, with the conversion temperature carefully maintained using a thermostated furnace to achieve uniform particle formation and a well-defined phase composition. Nebulization and aerosol generation took place in an oxygen-rich atmosphere, with a regulated gas flow rate of 2 dm^3 min^{-1}, while the synthesis temperature was consistently held at 800 °C. These parameters enabled the development of CoCeY (∑M) composite structures with the required crystallinity and morphology, providing a stable and suitable framework for further catalyst modification. After the synthesis of oxide supports, the materials were subjected to microwave hydrothermal treatment in the presence of $IrCl_3$ while maintaining a stable temperature, resulting in composite structures with tailored IrO_2 mole ratios (∑M:Ir = 3:7 and ∑M:Ir = 7:3). The catalytic performance of the synthesized thin-layer composites for OER was assessed through polarization measurements in acidic media. Electrochemical structure-activity relationships were further examined using impedance spectroscopy, providing insights into charge transfer properties and interfacial kinetics. Additionally, the impact of post-synthesis thermal treatment on the structural and electrochemical properties of the composites was investigated. A strong correlation between structural parameters, physicochemical state, composition, and OER activity was identified, offering valuable guidance for the design of advanced, cost-effective electrocatalysts.

Keywords: *oxygen evolution activity; anode durability; water splitting; activity distribution through bulk powders.*

***Acknowledgement**: Authors wish to acknowledge the support of the Science Fund of the Republic of Serbia PROJECT NUMBER 6666, Renewal of the Waste Oxygen-Evolving anodes from Hydrometallurgy and their improved Activity for Hydrogen Economy, Wastewater and Soil Remediation - OxyRePair.*

MICROWAVE Ir OXIDE-ENCAPSULATED SPRAY PYROLITIC MICROSPHERES OF RARE EARTH OXIDES AS AN ELECTROCATALYST FOR OXYGEN EVOLUTION

Katarina Đ. Božić[1,2*], Marijana R. Pantović Pavlović[1,2], Maja R. Stevanović[3], Marija D. Mihailović[1], Miroslav M. Pavlović[1,2], Jasmina S. Stevanović[1,2], Vladimir V. Panić[1,2,4]

*[1]University of Belgrade - Institute of Chemistry, Technology and Metallurgy - National Institute of the Republic of Serbia, Department of Electrochemistry, Njegoševa 12, Belgrade, Serbia, katarina.bozic@ihtm.bg.ac.rs**
[2]Center of Excellence in Environmental Chemistry and Engineering, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, Belgrade, Serbia
[3]University of Belgrade, Innovation Center of Faculty of Technology and Metallurgy, Karnegijeva 4, Belgrade, Serbia
[4]State University of Novi Pazar,Vuka Karadžića bb, Novi Pazar, Serbia

Abstract

Water electrolysis, powered by sustainable energy sources, represents a key technology for a green hydrogen production, offering a clean and renewable energy solution. However, the efficiency of this process is primarily constrained by the sluggish kinetics of the oxygen evolution reaction (OER), which significantly increases the overall energy demands. To overcome this limitation, highly active and stable OER catalysts are required to enhance reaction efficiency and reduce energy losses. Among the known OER catalysts, iridium (IV) oxide (IrO_2) is considered the most effective due to its exceptional activity and durability in acidic environments. Nevertheless, given the high cost and scarcity of iridium, optimizing its utilization and catalytic efficiency is crucial. This can be achieved through the development of advanced synthesis strategies and the incorporation of interactive supporting materials that enhance catalytic performance while minimizing Ir consumption. This study presents an innovative synthesis approach that combines ultrasonic spray pyrolysis (USP) for the preparation of rare-earth-based oxide as catalyst carrier with their subsequent microwave hydrothermal encapsulation by IrO_2. Ce/Y ($\sum$M) oxide supports were synthesized using a one-step USP process in which precursor aqueous solutions of $CeCl_3$ and $Y(NO_3)_3$ were mixed in mole ratios of Ce:Y=4:1 and Ce:Y=1:4. The conversion temperature during spray pyrolysis was regulated using a thermostated furnace, ensuring uniform particle formation and phase composition. The nebulization and aerosol formation process was carried out in an oxygen atmosphere, with a controlled carrier gas (oxygen) flow rate of 2 $dm^3\ min^{-1}$, while the synthesis temperature was maintained at 800 °C to promote the formation of CeO_2/Y_2O_3 composite structures with the desired crystallinity and morphology. Following the synthesis of oxide USP powders, the materials were further processed via microwave hydrothermal treatment in the presence of $IrCl_3$ under constant temperature conditions, leading to the formation of composite materials with varying IrO_2 mole ratios (projected to $\sum$M:Ir=3:7 and $\sum$M:Ir=7:3). The resulting composites of IrO_2-shelled CeO_2/Y_2O_3 microspheres were systematically characterized to assess their electrochemical properties and catalytic activity for OER. Particular emphasis was placed on evaluating the synergistic effects of CeO_2 and Y_2O_3 within the composite structures, as well as their role in enhancing the catalytic performance of IrO_2. The study provides insight into how the interaction between these oxide catalyst carriers and IrO_2 influences overall OER efficiency, shedding light on potential strategies for improving the sustainability and cost-effectiveness of high-performance water-splitting catalysts.

Keywords: *oxygen evolution reaction; oxygen-evoloving anodes; electrocatalytic powders; electrochemical charaterization of powders.*

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THEORETICAL ASSESSMENT OF PMMA'S POTENTIAL TO REMOVE BETA-BLOCKERS FROM THE AQUATIC ENVIRONMENT USING ATOMISTIC CALCULATIONS

Svetlana Pelemiš[1], Andrijana Bilić[2,3], Dušica Krunić[4], Sanja J. Armaković[2,3*], Stevan Armaković[3,4]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina*
[2]*University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, Novi Sad, Serbia, sanja.armakovic@dh.uns.ac.rs**
[3]*Association for the International Development of Academic and Scientific Collaboration (AIDASCO), Sutjeska 2, Novi Sad, Serbia*
[4]*University of Novi Sad, Faculty of Sciences, Department of Physics, Trg Dositeja Obradovića 4, Novi Sad, Serbia*

Abstract

Water stress is a significant issue globally, with many regions experiencing water scarcity. The main challenge in achieving effective wastewater treatment is maximizing the overall efficiency of treatment systems. Polymers play a significant role in environmental applications, particularly in water treatment systems. Certain pharmaceuticals, such as β-blockers like salbutamol and atenolol, are emerging contaminants commonly found in water sources. These substances pose considerable risks due to their persistence and bioactivity. Polymethyl methacrylate (PMMA) is a polymer with excellent mechanical, optical, and electrical properties. It is also economical, non-toxic, and insoluble in water, making it an ideal material for water remediation. Understanding the molecular interactions between these pharmaceuticals and PMMA is essential for optimizing filtration and purification technologies. The atomic calculations provide a detailed understanding of the interaction between molecules without the need for expensive equipment. This study presents a computational analysis of how the polymethyl methacrylate interacts with salbutamol and atenolol. Geometrical optimizations were performed using semiempirical and density functional theory (DFT) calculations. To identify significant interactions between PMMA and pharmaceuticals, we employed the reduced density gradient (RDG) approach, providing insight into intramolecular noncovalent interactions between PMMA's atoms and pharmaceutical molecules. These findings illuminate the fundamental mechanisms of PMMA interactions with pharmaceuticals, offering valuable insights for its use in the environmental remediation of pharmaceutical pollutants.

Keywords: *water purification, salbutamol, atenolol, polymers, DFT, RDG*

ORGANIC NANOCONE STRUCTURES AS SENSORS FOR METFORMIN DETECTION

Svetlana Pelemiš[1], Dušica Krunić[2], Andrijana Bilić[3,4], Iris Maglovski[5], Sanja J. Armaković[3,4], Stevan Armaković[2,4*]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina*
[2]*University of Novi Sad, Faculty of Sciences, Department of Physics, Trg Dositeja Obradovića 4, Novi Sad, Serbia, stevan.armakovic@df.uns.ac.rs**
[3]*University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, Novi Sad, Serbia*
[4]*Association for the International Development of Academic and Scientific Collaboration (AIDASCO), Sutjeska 2, Novi Sad, Serbia*
[5]*University of Belgrade, Faculty of Physics, Studentski trg 12, Belgrade, Serbia*

Abstract

In this study, we investigate the interactions between organic nanocone structures and metformin, a widely prescribed drug for managing high blood sugar levels. To gain deeper insights into binding affinities and noncovalent interactions, we employ a multiscale computational approach that integrates various levels of atomistic modeling. Initially, the semiempirical GFN2-xTB method is used to optimize the geometry of these large molecular systems efficiently. Subsequently, selected density functional theory calculations refine the electronic structure properties, focusing on charge distribution and interaction energies. By analyzing electron density topology and noncovalent interaction descriptors, we evaluate the nature, strength, and spatial distribution of intermolecular forces governing metformin adsorption. Additionally, a selected system consisting of a nanocone and a metformin molecule is subjected to molecular dynamics simulations to assess the dynamical properties of the interaction, including stability and binding persistence over time. These findings enhance our understanding of molecular recognition processes at the nanoscale, offering valuable insights for drug delivery, adsorption technologies, and biomedical applications.

Keywords: *adsorption, binding energies, noncovalent interactions, DFT, GFN2-xTB, MD*

EXAMINATION OF HYDROXYAPATITE APPLICATION AS A POTENTIAL QUERCETIN - CARRYING MATERIAL

Ivan Bracanović[1*], Aleksandar Krstić[2], Miloš Simić[1], Miljana Mirković[1], Ana Kalijadis[1]

*[1]University of Belgrade, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Department of Materials, Mike Petrovića Alasa 12-14, Belgrade, Serbia, ivan.bracanovic@vin.bg.ca.rs**

[2]University of Belgrade, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Department of Physical Chemistry, Mike Petrovića Alasa 12-14, Belgrade, Serbia

Abstract

The objective of this work was to investigate a naturally occurring mineral form of calcium apatite, known as hydroxyapatite (Hap), as a potential drug delivery material. Drug delivery materials are utilized to effectively administer drugs to the body, ensuring controlled release, targeted delivery, and enhanced bioavailability. Hydroxyapatite was selected for its widespread use in biomedical applications, attributed to its exceptional biocompatibility, bioactivity, and osteoconductivity. As the main mineral component of human bone and teeth, it is highly appropriate for medical and dental implants, coatings, and bone grafts. Moreover, hydroxyapatite exhibits low biodegradability under physiological conditions, and its surface can be modified to improve protein adsorption and cell attachment, ensuring stability for long-term use. Hydroxyapatite was prepared for drug delivery purposes using the wet precipitation method of NaH_2PO_4 + H_2O into $Ca(OH)_2$. This solution was magnetically stirred, and the pH of the mixture was adjusted with NH_4OH to create an alkaline environment at a temperature of around 80 °C. The adsorption experiment was conducted with the well-known flavonoid quercetin, chosen due to its challenging bioavailability, attributed to factors such as low aqueous solubility, a short metabolic period, and toxicity. A quercetin solution was prepared in ethanol with a concentration of 5 ppm. The adsorption experiment was carried out over 24 hours with constant stirring at room temperature. The results were analyzed using a UV-VIS spectrophotometer. Quercetin exhibits two peaks in the UV-VIS spectrum that are between 240–280 nm and 340–440 nm. Results showed that 3,3 mg/g of quercetin was attached tothe hydroxyapatite surface.It was also shown that quercetin was attached to the surface of the hydroxyapatite by intermolecular interactions. The most dominant one is the hydrogen bond, which belongs to the group of dipole-dipole interactions, that occur between the hydroxyl groups of quercetin and the oxygen atoms of the phosphate group in hydroxyapatite.

Keywords: *drug-carrier, hydroxyapatite, quercetin, adsorption, UV-VIS spectrum, hydrogen bond*

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ANTIMICROBIAL PROPERTIES OF HYDROXYAPATITE MATERIAL OBTAINED BY GREEN TECHNOLOGY PATHWAY

Ivan Bracanović[1*], Dunja Miletić[2], Ana Kalijadis[1], Miloš Simić[1], Aleksandar Krstić[3], Aleksandra Sknepnek[2], Miljana Mirković[1]

*[1]University of Belgrade, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Department of Materials, Mike Petrovića Alasa 12-14, Belgrade, Serbia, ivan.bracanovic@vin.bg.ca.rs**
[2]University of Belgrade, Faculty of Agriculture, Nemanjina 6, Zemun, Serbia
[3]University of Belgrade, „VINČA" Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Department of Physical Chemistry, Mike Petrovića Alasa 12-14, Belgrade, Serbia

Abstract

Due to increasingly intense problems in terms of resistance to various types of infections, including bacterial resistance to antibiotics, new materials with effective contact antimicrobial action are intensely being researched. Hydroxyapatite (HAp) represents the leading material from the calcium-phosphate group, which can be used as a biocompatible material, in environmental protection as an adsorbent for heavy metal removal from polluted waters, and also as an antimicrobial agent. The wide specturm of use of this material lies in its structural and functional properties. The main goal of this work was to obtain pure nanocrystalline hydroxyapatite material, using green technologies, i.e. precursors that are ecologically acceptable for the environment such as hydrogen phosphates as a source of PO4 and hydroxide as a source of Ca. Synthesized HAp nanocrystalline material was structurally investigated by X-ray diffraction method and morphological properties are investigated by scanning electron microscopy method. Based on obtained results pure nanocrystalline material was obtained with average crystallite sizes about 10 nm and hexagonal symmetry. The microstructural results confirms proper crystal grains small in sizes agglomerated in larger forms. The antibacterial activity of the obtained HAp was tested against Gram-positive bacteria Staphylococcus aureus, Listeria monocytogenes, and Gram-negative bacteria Pseudomonas aeruginosa and Acinetobacter baumanii by total plate count assay. Results shows that obtained material posses the best antimicrobial properties against Staphylococcus aureus with 50% and Acinetobacter baumanii with 45% of efficiency while for Pseudomonas aeruginosa and Lysteria monocytogenes shows 20% and 8% of efficiency compared to the control. Obtained HAp material at a concentration of 50 mg/mL showed a reducing property towards the bacteria.

Keywords: *hydroxyapatite, antimicrobial, structure, green technologies.*

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ELECTROCHEMICAL DEPOSITION OF NICKEL COATING ON COPPER

Stanko Spasojević[1*], Milena Milovanović[2], Danijela Jovičić[1], Stana Stanišić[1], Zorica Ristić[1], Marija Mitrović[2], Bojana Lukić[1], Milorad Tomić[2,3]

[1]*ORAO, a.d. Šabačkih đaka бб, Bijeljina, Republic of Srpska, Bosnia and Herzegovina, stankos.1997@gmail.com**
[2]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosna and Hercegovina;*
[3]*Engineering Academy of Serbia, Kneza Miloša 9/IV, Belgrade, Serbia*

Abstract

This work investigates the process of forming metallic coatings of nickel on copper using electrolytic deposition. By focusing on the optimization of deposition parameters, such as current density, electrolyte temperature and deposition time, high-quality coatings can be achieved in terms of corrosion resistance, strength, adhesion and aesthetic appearance of the material.
In the experimental part of this work, copper samples were treated with nickel-based electrolytes at different parameters of deposition time and current density while the temperature was constant. In the process of electrochemical deposition, the cathodes are copper plates, and the anodes are electrolytic Ni 99.999%. Electrochemical nickel coatings were deposited for 10, 15, and 20 minutes at current densities of 1, 1.5, and 2 A/dm², at a bath temperature of 42°C.
The results show that deposition parameters significantly affect the morphology and physical-mechanical properties of the formed layers. With an increase in the current density, there is an increase in the thickness of the metal coating deposited on the surface of the copper, as well as with an increase in the time of the electrochemical process.
Based on the obtained data, the work provides very important guidelines for the optimization of the process of electrochemical deposition of nickel on copper in industrial applications.

Keywords: *copper, nickel coating, electrochemical deposition, hardness, adhesion, coating thickness.*

DEPOSITION OF BRIGHT ELECTROCHEMICAL NICKEL COATINGS ON STEEL

Stanko Spasojević[1], Stana Stanišić[1], Danijela Jovičić[1], Zorica Ristić[1], Dubravka Banjac[1], Snježana Vučićević[2]*, Marija Mitrović[2], Milorad Tomić[2,3]

[1] ORAO, a.d. Šabačkih đaka bb, Bijeljina, Republic of Srpska, Bosnia and Herzegovina
*[2]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska,Bosnia and Herzegovina, snjezanavucicevic66@gmail.com**
[3]Engineering Academy of Serbia, Kneza Miloša 9/IV, Belgrade, Serbia

Abstract

The characteristics of nickel coatings obtained by electrochemical deposition on steel samples of known chemical composition were investigated. The chemical composition of the steel was examined using the XRF method (X-ray fluorescence spectrometry) before and after the deposition of the coatings. The effect of current density and deposition time on the cathodic current efficiency, coating thickness, hardness, and adhesion of the electrochemically obtained nickel coatings was analyzed. The preparation of the steel samples was carried out in the same way using glass spherical beads. Nickel coatings were electrochemically deposited onto the prepared steel samples from three baths in an electrochemical reactor with a volume of 64 dm³. All three used baths were based on Vatov's electrolyte: (30-50 g/dm³ $NiCl_2 \cdot 6H_2O$, 15-30 g/dm³ H_3BO_3, 200-250 g/dm³ $NiSO_4 \cdot 7H_2O$). In bath 1, in addition to the standard Vatov electrolyte, the following were added: basic additive 302 (5 cm³/dm³), wetting additive 304 (8 cm³/dm³), and ductility additive 305 (12 cm³/dm³), (all additives from the company "Protekta" Belgrade). Compared to bath 1, baths 2 and 3 also had additives for brightness. In bath 2, a high-brightness additive 301 (0.5 cm³/dm³) from the company "Protekta" Belgrade was added, and in bath 3, sulfosalicylic acid (0.5 cm³/dm³) of p.a. purity. Electrochemical nickel coatings were deposited for 10, 15, and 20 minutes at current densities of 1, 1.5, and 2 A/dm², at a bath temperature of 42°C. Based on the mass increase of the samples due to electrochemical nickel deposition, the cathodic current efficiency and coating thickness were calculated. The roughness of the coatings was measured using a "Mitutoyo" device, and hardness was determined by the Vickers method. The adhesion of the nickel coatings was tested using the bending method. It was observed that with increasing current density and deposition time, the cathodic current efficiency increased, and thicker nickel coatings were obtained. Under the same deposition conditions, nickel coatings of approximately the same thickness were obtained from all three baths, leading to the conclusion that brightness additives do not significantly affect the thickness of electrochemical nickel coatings but do affect their compactness and brightness. Nickel coatings obtained under the given conditions from all three baths meet the requirements for good adhesion.

Keywords: *nickel coatings, electrochemical deposition, current density, roughness, current efficiency, hardness, adhesion, coating thickness*

THE EFFICACY OF *THYMUS SERPILLUM* EXTRACT IN MITIGATING STEEL CORROSION IN HCL SOLUTION

Marija Mitrović[1*], Milorad Tomić[1,2], Bojan Gorančić[1], Nebojša Vasiljević[1], Regina Fuchs-Godec[3], Dragan Tošković[1]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina, marija.ridjosic@tfzv.ues.rs.ba**
[2]*Engineering Academy of Serbia, Kneza Milosa 9/IV, Belgrade, Serbia*
[3]*University of Maribor, Faculty of Chemistry and Chemical Engineering, Smetanova ulica 17, Maribor, Slovenia*

Abstract

The inhibitory effect of Thyme (Thymus serpillum) extract (TSE) on the corrosion of two steel types in 4% HCl solutions was investigated (Steel 1 - DC01 and Steel 2 - X5 CrNi 18-10). Steel samples were chemically prepared followed by the examination of corrosion rate in both uninhibited and inhibited HClsolutions. Four solutions were used: Solution 1: 4% HCl, Solution 2: 4% HCl + 0.5g/L TSE, Solution 3: 4% HCl + 1g/L TSE, and Solution 4: 4% HCl + 1.5g/L TSE. Corrosion resistance of steel in examined solutions was determined by weight loss and electrochemical impedance spectroscopy methods. The samples were immersed in the solutions for 2h, 4h, 6h, 8h, 24h, 48h, and 168h. Corrosion indicators such as corrosion rate (π), and the inhibitor protective factor (z) were calculated according to data obtained by weight loss method. The highest protection factor of TSE in 4% HCl was 94.42% for steel 1 at 1.5 g/L, and 96.61% for steel 2 at 1.0 g/L, demonstrating the effectiveness of TSE as a corrosion inhibitor. Electrochemical impedance spectroscopy results showed the increase in corrosion resistance of both steel types with increase in inhibitor concentration in HCl solution, supporting the obtained weight loss results.

Keywords: *thyme extract, green inhibitors, corrosion, protection factor, electrochemistry.*

EVALUATION OF THE INHIBITORY EFFECT OF DANDELION ROOT EXTRACT IN HCL SOLUTION BY STATISTICAL ANALYSIS

Nebojša Vasiljević[1,2*], Marija Mitrović[1], Regina Fucsh-Godec[3], Dragan Tošković[1], Milorad Tomić[1,4]

[1] *University of East Sarajevo, Faculty of Technology Zvornik, Zvornik, Republic of Srpska, Bosnia and Herzegovina, nebojsa.vasiljevic@tfzv.ues.rs.ba**
[2] *University of Novi Sad, Faculty of Technology, Novi Sad, Republic of Serbia*
[3] *University of Maribor, Faculty of Chemistry and Chemical Engineering, Maribor, Slovenia*
[4] *Engineering Academy of Serbia, Belgrade, Serbia*

Abstract

In this paper, the influence of steel type, inhibitor concentration, and time on the inhibitory effect of dandelion root extract in a 4% HCl solution was investigated. Two types of steel of known composition were used, and the inhibitory effect was monitored in a time interval of 2, 4, 6, 24 and 48 hours. Dandelion root extract was obtained by the Soxlet method with 96% ethanol, and then dilutions (0.5 g/l, 1.0 g/l and 1.5 g/l) were made from the obtained extract in 4% HCl solution. The optimization of the experimentally obtained results was done using the MINITAB 21 software. The optimal concentration of dandelion roots in 4% HCl solution for inhibitory effect is 1.5 g/l, while time has no great influence on the inhibitory effect because the beneficial effect was achieved already after 2 hours. Also, better inhibition efficiency was observed in steel type 1.

Keywords: *Corrosion, Dandelion roots, Optimization, Inhibitor.*

ADSORPTION OF METHYLENE BLUE FROM AQUEOUS SOLUTION BY CARBON MATERIALS: A KINETIC STUDY

Ivan Bracanović[1*], Ana Kalijadis[1], Miloš Simić[1], Aleksandar Krstić[2]

*[1]Vinča Institute of Nuclear Sciences, Department of Materials, Mike Petrovića Alasa 12-14, Vinča, Belgrade, Serbia; ivan.bracanovic@vin.bg.ac.rs**
[2]Vinča Institute of Nuclear Sciences, Department of Physical Chemistry, Mike Petrovića Alasa 12-14, Vinča, Belgrade, Serbia;

Abstract

This study aimed to investigate the kinetic properties of methylene blue adsorption on carbon cryogel samples and nitrogen doped and nitrogen and sulfur co-doped carbon cryogel. Nitrogen and sulfur were incorporated into the carbon structure to enhance surface, electronic and textural properties. Methylene blue, a widely utilized dye in the textile industry, has become one of the most commonly detected substances in water systems. Experimental data were fitted with four kinetic models and showed excellent fits with the linear pseu-do-second-order model. Results confirmed satisfactory kinetic properties of all investigated samples without significant influence of doped nitrogen and sulfur on adsorption.

Keywords: *carbon cryogel, nitrogen doped, nitrogen and sulfur co-doped, water contamination, adsorption, methylene blue.*

PHYTOCHEMICALS AND ANTIOXIDANT ACTIVITIES OF SARAWAK BARIO RICE VARIETIES

Macdalyna Esther Ronie[1], Hasmadi Mamat[1*], Ahmad Hazim Abdul Aziz[1], Mohamad Khairi Zainol[2], Norazlina Mohammad Ridhwan[1], Rovina Kobun[1], Nicky Rahmana Putra[3]

*[1] University Malaysia Sabah, Faculty of Food Science and Nutrition, Food Safety and Security Research Laboratory, Kota Kinabalu, Sabah, Malaysia, idamsah@ums.edu.my**
[2] University Malaysia, Faculty of Fisheries and Food Science, Kuala Terengganu, Malaysia
[3] National Research and Innovation Agency, Research Center for Pharmaceutical Ingredients and Traditional Medicine, Bogor, Indonesia

Abstract

Rice is a staple diet for almost half of the world's population, offering a diverse range of varieties with distinct characteristics, including pigmented and non-pigmented types. Phenolic and flavonoid compounds in food are acknowledged for their health-promoting benefits and antioxidant properties. This research explores the total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity through the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity of different Bario rice varieties. Bario rice varieties are exotic local crops that originated from Sarawak, Malaysia. These crops have gained a reputation due to their excellent eating quality and natural aroma upon cooking. The study found that the pigmented rice exhibited higher phenolic content compared to non-pigmented. Similar trends were observed in TFC, favouring the pigmented rice varieties. Bario Merah Sederhana indicated the highest TFC content, followed by Bario Celum (BC) and Bario Tuan. There was no significant difference ($p>0.05$) was observed among samples at the highest concentration level (3.5 mg/ml). The DPPH radical scavenging assay underscores the strong antioxidant potential of pigmented rice, particularly BC, the black-pigmented rice. The antioxidant activity was attributed to the presence of rice bran, which is rich in phytochemicals, contributing to a greater antioxidative effect. The study highlighted the promising potential of Bario rice varieties, as revealed by their phytochemicals and antioxidant capacity, indicating their potential contribution to human well-being.

Keywords: *antioxidant, bario rice, dpph scavenging assay, total phenolic content, total flavonoid content.*

CADMIUM, LEAD, ARSENIC AND MERCURY IN FOOD SOLD ON THE LOCAL MARKET IN THE REPUBLIC OF SERBIA

Milana Lazović[1,2], Vladimir Tomović[1*], Isidora Kecojević[1,2], Danica Mrkajić[1,2], Biljana Bajić[2], Ana Joksimović[2], Mila Tomović[3], Dragan Vujadinović[4]

[1]*University of Novi Sad, Faculty of Technology Novi Sad, Bulevar cara Lazara 1, Novi Sad, Serbia, tomovic@uns.ac.rs**
[2]*A BIO TECH LAB d.o.o., Vojvode Putnika 87, Sremska Kamenica, Serbia*
[3]*Technical School "Pavle Savić", Šajkaška 34, Novi Sad, Serbia*
[4]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Bosnia and Herzegovina*

Abstract

Food, especially cereals and vegetables, water and air are the major source of exposure to toxic metals like cadmium (Cd), lead (Pb), arsenic (As) and mercury (Hg). Their accumulation in the human body can lead to harmful effects over time. The EFSA panel on contaminants in the food chain (CONTAM) established a tolerable weekly intake (TWI) for Cd, Pb, As and Hg of 2.5, 25, 15 and 4 μg kg^{-1} body weight, respectively.

The concentrations of Cd, Pb, As and Hg were determined in different food groups (Grain, mill and bakery products, pasta and pasta products; Soybean; Coffee bean; Sugar; Candy products; Seasonings – Table 1). The samples were analysed by inductively coupled plasma – optical emission spectrometry (ICP-OES). The concentrations of Cd, Pb, As and Hg in the food were compared to the maximum levels set by the European Union and the Serbian legislation.

Cd concentrations in the grain, mill and bakery products, pasta and pasta products ranged from <0.01 to 0.038 mg kg^{-1}, Pb concentrations ranged from <0.01 to 0.092 mg kg^{-1}, and As concentrations ranged from <0.01 to 0.283 mg kg^{-1}. Cd concentrations in the seasonings ranged from <0.01 to 0.036 mg kg^{-1}, Pb concentrations ranged from <0.01 to 0.094 mg kg^{-1}, and As concentrations ranged from <0.01 to 0.212 mg kg^{-1}. As concentrations in the sugar ranged from <0.01 to 0.470 mg kg^{-1}. Cd, Pb and As concentrations were less than 0.010 mg kg^{-1} in all samples of soybean, coffee bean, and candy products. In addition, Cd and Pb concentrations were also less than 0.010 mg kg^{-1} in all sugar samples. Hg concentrations were less than 0.010 mg kg^{-1} in all analysed samples. The maximum level of Cd was found in a frozen puff pastry sample (0.038 mg kg^{-1}), the maximum level of Pb was found in a savoury condiment sample (0.094 mg kg^{-1}) and the maximum level of As was found in a sugar sample (0.470 mg kg^{-1}). In all analyzed samples, Cd, Pb, As and Hg concentrations are lower than maximum levels set by the European Union and Serbian legislation.

Keywords: *cadmium, lead, arsenic, mercury, food.*

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DETERMINATION OF THE CONTENT OF HEAVY METALS AND NITRITES IN MEAT PRODUCTS (PATES AND MEAT SPREADS) FROM THE MARKET OF THE REPUBLIC OF SRPSKA

Dragan Tošković[1], Danijela Rajić[1], Marija Mitrović[1], Vesna Gojković Cvjetković[1], Milomirka Obrenović[1*]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Bosnia and Herzegovina, milomirkaskrba95@gmail.com**

Abstract

Animal-based food is significant for human nutrition as it represents an easily digestible source of high-quality proteins, fatty acids, fat-soluble vitamins, and energy. Throughout evolution, humans developed anatomical, metabolic, and biochemical adaptations in the digestive tract, increasing dependence on nutritionally valuable food, such as animal-based products. Animal-based food can be a source of chemical substances harmful to health, such as contaminants (heavy metals, mycotoxins, organochlorine pesticides, dioxins, polychlorinated biphenyls, polycyclic aromatic hydrocarbons...), veterinary drug residues, and additives. The subject of this paper is the determination of the content of essential (copper Cu, iron Fe, and chromium Cr), heavy and toxic (lead Pb, cadmium Cd, arsenic As, and tin Sn) metals, as well as nitrites in meat products, particularly pâtés and meat spreads available in the market of the Republic of Srpska. Determination content of metals was performed using the ICP-OES method, while nitrites were analyzed using the standard SRPS ISO 2918/1999 method. The obtained results indicate that the content of heavy and toxic metals and nitrites is lower than the maximum prescribed by national regulations, namely the Rulebook on Maximum Amounts of Certain Contaminants ("Official Gazette of BA", No. 68/14, 79/16, 84/18) and the Rulebook on Additives in food ("Official Gazette of BA", No. 33/18 and 6/21).

Keywords: *liver pâté, meat spread, heavy metals, nitrites.*

DETERMINATION OF THE CONTENT OF HEAVY METALS IN SAMPLES OF STERILIZED VEGETABLES: PEAS AND GREEN BEANS ON THE MARKET OF THE REPUBLIC OF SRPSKA

Dragan Tošković[1], Danijela Rajić[1], Marija Mitrović[1], Vesna Gojković Cvjetković[1], Milomirka Obrenović[1*]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Bosnia and Herzegovina, milomirkaskrba95@gmail.com**

Abstract

Heavy metals are natural components of the Earth's crust. They are highly persistent, so the total amount of their emissions from both natural and human technological activities accumulates in the soil and water. Due to their persistence, high toxicity, and tendency to accumulate in ecosystems, heavy metals pose a threat to living organisms. The aim of this paper is to determine contents of heavy metals-arsenic, cadmium, chromium, copper, iron, nickel, manganese, lead, tin, and zinc—in samples of sterilized vegetables: peas and green beans, packaged in white tin cans from different manufacturers on the market of the Republic of Srpska. The samples were mechanically homogenized and then dissolved using microwave digestion with the addition of HNO_3 and H_2O_2 (9:1) in a Milestone ETHOS device. Heavy metal content was determined by optical emission spectroscopy with inductively coupled plasma (ICP-OES Shimadzu 9820). In the tested samples (1-3 sterilized peas; 4-6 sterilized green beans), the arsenic content was 0.1066-0.2713 mg/kg for sterilized peas, 0.1532-0.1997 mg/kg for sterilized green beans, cadmium 0.0291-0.0371mg/kg for sterilized peas, 0.0252-0.0322 mg/kg for sterilized green beans and zinc 15.6214-17.1989 mg/kg for sterilized peas, 12.5842-14.3345mg/kg for sterilized green beans. The content of copper was 3.4183-4.4987 mg/kg for sterilized peas, 3.9921-4.5641mg/kg for sterilized beans, iron 16,3141-26.1358 mg/kg for sterilized peas, 31.3026-38,8898mg/kg for sterilized green beans, and nickel 0.2035-0.2083 mg/kg for sterilized peas, 0.0850-0.1850 mg/kg for sterilized geen beans. The content of manganese was 6.1358-10.0002 mg/kg for sterilized peas, 8.8898-11.4111 mg/kg for sterilized green beans and lead 0.1271-0.1515 mg/kg for sterilized peas and 0.1213-01841 mg/kg for sterilized green beans. In all samples concentrations was within the permissible limits prescribed by domestic and European Union regulations. White tin is the most used material for packaging food products. In the tested samples, the content of tin 113.1459-124.8616 for sterilized peas, 124.2135-145.0031mg/kg for sterilized green beans and chromium 0.0081-0.0095 mg/kg for sterilized peas, 0.0085-0.0105 mg/kg for sterilized green beans was very low, confirming that there is no interaction between the contents of the can and the passivation film, that is, that the packaging - cans in perfect condition. The obtained results indicate that the content of heavy metals is lower than the maximum prescribed by national regulations, namely the Rulebook on Maximum Amounts of Certain Contaminants ("Official Gazette of BA", No. 68/14, 79/16, 84/18).

Keywords: *peas, green beans, sterilization, white tin, microwave digestion, ICP-OES.*

CARBON PASTE ELECTRODE MODIFIED WITH BIOCHAR FOR SENSITIVE ELECTROCHEMICAL DETERMINATION OF CARBENDAZIM IN ENVIRONMENTAL WATER SAMPLES

Jasmina Anojčić[1*], Sanja Mutić[1], Nina Đukanović[1], Tamara Apostolović[1], Tijana Marjanović Srebro[1], Jelena Beljin[1]

[1] *University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, Novi Sad, Serbia, jasmina.anojcic@dh.uns.ac.rs**

Abstract

Electrochemical sensing is considered one of the most relied upon non-destructive, commercially viable, and effective techniques for the rapid, sensitive, and on-site detection of pesticides. Recently, as a member of the carbon family, biochar (BC) has been increasingly of interest to researchers. BC properties can be utilized for electrode construction and fabricating cost-effective sensors for different target compounds. Since persistent organic pollutants accumulate in the environment and have potential toxicity, there is a requirement to develop selective and sensitive analytical methods such as voltammetric ones for the detection of low-concentration levels of persistent and frequently used pesticides in the environmental water samples. Herein, wheat-derived BC was used for bulk-modification of carbon paste electrode (CPE) to prepare simple and sensitive electrochemical sensor for a systemic broad-spectrum fungicide carbendazim (CBZ). Various parameters were optimized to access the best electroanalytical performance of the sensor, including the electrode composition, pH of the supporting electrolyte and adsorption parameters. The amount of BC in CPE ranged from 0 to 30 wt%, and the most pronounced oxidation signal of CBZ was obtained using 5% BC-CPE. The effect of the pH (2.0–11.98) of Britton-Robinson buffer on the shape and intensity of CBZ signal was also investigated, whereby the pH 6.0 was selected as optimal. Since the adsorption plays a significant role in the oxidation mechanism of CBZ, additional studies were performed using square wave adsorptive stripping voltammetry (SW-AdSV) regarding the optimization of accumulation potential (E_{acc}) and accumulation time (t_{acc}) of the target analyte on the electrode surface. Under optimized conditions (E_{acc}=-0.2 V, t_{acc}=60 s, pH 6.0), the BC-based CBZ sensor exhibits a linear concentration range from 1.25 to 50.0 ng mL^{-1} with a limit of detection 0.38 ng mL^{-1} and relative standard deviation lower than 2.5%. The practical applicability of the 5% BC-CPE was examined for the determination of CBZ in environmental water samples such as surface water and wastewater. The good recovery and reproducibility confirm the potential of the proposed BC-based sensor for the rapid and reliable determination of pesticides in contaminated water, offering a sustainable alternative to traditional methods.

Keywords: *carbendazim, biochar, carbon paste electrode, square wave adsorptive stripping voltammetry, surface water, wastewater.*

Acknowledgment: *This research was supported by the Science Fund of the Republic of Serbia, #10810, Sustainable solutions in environmental chemistry: exploring biochar potential–EnviroChar.*

COMPARISON OF WHEAT AND CORN-DERIVED BIOCHAR AS MODIFIERS OF CARBON PASTE ELECTRODE FOR VOLTAMMETRIC DETERMINATION OF CARBENDAZIM

Sanja Mutić[1*], Jasmina Anojčić[1], Nina Đukanović[1], Tamara Apostolović[1], Tijana Marjanović Srebro[1], Jelena Beljin[1]

[1] *University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, Novi Sad, Serbia, sanja.mutic@dh.uns.ac.rs**

Abstract

Revealing the different types of biomass as low-cost resources with high availability is a way of exploring biochar (BC) potential for environmental waste management. BC, as a versatile and sustainable solution, can deal with various environmental pollutants, such as pesticides, in different environmental samples. The corn (CBC) and wheat (WBC)-derived biochars were synthesized at two pyrolysis temperatures, 400 °C (BC400) and 700 °C (BC700), and characterized using scanning electron microscopy (SEM). The effect of pyrolysis temperature on BC surface structure was recognized by the distinct difference in the morphology of CBC and WBC. Observed properties of the synthesized BCs led to a possibility for good electrocatalytic properties, which consequently are considered as possible material for modification of carbon paste electrode (CPE) comprised of graphite powder and paraffin oil. The electrochemical performance of the prepared BC-CPEs was evaluated by electrochemical impedance spectroscopic (EIS) and cyclic voltammetric (CV) measurements of the redox couple $[Fe(CN)_6]^{3-/4-}$. BC positively affects the electrochemical performance of the electrodes, which is attributed to an increase in the current intensity of the redox peaks, and to better reversibility due to the higher electron transfer rate. The electrochemical response is influenced by used modifiers in depending of conductivity of the electrode surfaces, and the WBC700-CPE produced the lowest peak separation value and the highest peak currents of redox probe compared to the unmodified CPE, CBC400-CPE, CBC700-CPE and WBC400-CPE. The observed electrochemical behavior of designed BC-modified CPEs suggests the ability to detect electroactive analytes such as broad-spectrum fungicide carbendazim (methyl-1H-benzimidazol-2-yl-carbamate, CBZ) deemed as a persistent organic pollutant. CV experiments showed that CBZ exhibits an irreversible behavior with a well-defined oxidation peak around 0.9 V at pH 5.0. Among the tested working electrodes for CBZ sensing, WBC700-CPE showed the most favorable interactions with the target analyte. The obtained results emphasize the enormous potential and bright future of WBC700-CPE with good catalytic activity and electron transfer ability for sensitive electroanalytical determination of CBZ in food and various environmental samples.

Keywords: *persistent organic pollutant, carbendazim, electrochemical sensor, carbon paste electrode, biochar, voltammetry.*

Acknowledgment: *This research was supported by the Science Fund of the Republic of Serbia, #10810, Sustainable solutions in environmental chemistry: exploring biochar potential–EnviroChar.*

ION EXCHANGE OF Na^+ IONS WITH H^+ IONS ON ZSM-5 ZEOLITE USING ACETIC ACID

Aleksandar Došić[1], Milomirka Obrenović[1*], Zoran Obrenović[1,2], Jelena Vuković[1], Ivan Savić[3]

[1]*University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina, milomirkaskrba95@gmail.com**
[2]*Alumina doo, Karakaj bb, Zvornik, Republic of Srpska, Bosnia and Herzegovina*
[3]*University of Niš, Faculty of Technology in Leskovac, Leskovac, Republic of Serbia*

Abstract

Based on previous research into the acid-base and ion-exchange properties of ZSM-5 zeolite, there is a need to explore the possibility of ion exchange on high-silica ZSM-5 zeolite with commercially available chemicals, while simultaneously monitoring changes in the structural and morphological characteristics of the zeolite, as well as the stability of its crystal structure. Since ZSM-5 zeolites are primarily used in catalytic processes in the petrochemical industry, particularly in acid-catalyzed hydrocracking reactions, it is very important to ensure an adequate number of acidic sites for more efficient catalytic activity. Therefore, this study investigated the possibility of exchanging sodium ions with hydrogen ions on ZSM-5 zeolite with a molar ratio of (SiO_2/Al_2O_3 = 1000) using an ion-exchange process with acetic acid. By employing various instrumental methods (XRD, FT-IR), along with chemical analysis of ZSM-5 zeolite samples, the influence of hydrogen ion concentration on the chemical composition and structural characteristics of ZSM-5 zeolite was monitored at different acid concentrations and exchange times. It was shown that ion exchange with acetic acid leads to a significant reduction in sodium content even with less concentrated solutions, while maintaining the stability of the crystal structure of ZSM-5 (SiO_2/Al_2O_3 = 1000) and a high degree of crystallinity. The degree of ion exchange with acetic acid is very high (around 90%) even after just one hour of ion exchange.

Keywords: *ion exchange, acetic acid, ZSM-5, zeolite.*

SAGE (Salvia officinalis) ESSENTIAL OIL: CHEMICAL COMPOSITION AND ANTIBACTERIAL AND ANTIOXIDANT ACTIVITY

Vesna Antunović[1*], Željka Marjanović Balaban[2], Aleksandra Šmitran[3], Nebojša Kladar[4],

*[1]University of Banja Luka, Faculty of Medicine, Department of Pharmacy, Bulevar vojvode Petra Bojovića 1A, Banja Luka, Bosnia and Herzegovina, vesna.antunovic@med.unibl.org**
[2]University of Banja Luka, Faculty of Forestry, Bulevar vojvode Petra Bojovića 1A, Banja Luka, Bosnia and Herzegovina
[3]University of Banja Luka, Faculty of Medicine, Department of Microbiology and Immunology, Save Mrkalja 14, Banja Luka, Bosnia and Herzegovina
[4]University of Novi Sad, Faculty of Medicine, Department of Pharmacy, Hajduk Veljkova 3, Novi Sad, Serbia

Abstract

In recent years, the focus has been on the use of natural medicinal products in the treatment of all types of diseases. Essential oils obtained from medicinal plants have been known since ancient times as products with healing properties. Sage (Salvia officinalis), a plant from the family Luminacea, is one of the most valued medicinal plants primarily because it is rich in essential oil and because of its wide range of medicinal properties. It has been applied in the treatment of mental and nervous disorders. It is an anti-inflammatory, spasmolytic, antiseptic, antimicrobial, and antioxidant. Sage is also considered Generally Recognized As Safe (GRAS) for use as spices, other natural seasonings, and flavorings. In this paper, the focus is on the composition and characteristics of cultivated sage essential oil collected from the area of Mostar. The essential oil was isolated by the hydrodistillation method in the Clevenger apparatus. The chemical composition was determined by gas chromatography coupled with a mass detector (GC-MS). Twelve constituents were identified, corresponding to 96,89% of present compounds. The main components were camphor (30,25%), alpha-tujone (29,65%), 1,8-cineol (12,44%), and terpinen-4-ol (6,36). Antibacterial activity against Staphylococcus aureus ATCC 25923 and Escherichia coli ATCC 25922 was determined. The results are very promising and have shown bacterial sensitivity to the testing substance. The Salvia officinalis essential oil also exhibited significant DPPH radical scavenging activity, highlighting its potential as an antioxidant. The essential oil was tested on three concentrations (5, 10, and 15 mg/mL) with different times of incubation (20 and 60 min). The results revealed that inhibition of DPPH radical rises with concentration and finally reached a value of 73% (20 min incubation) and 77% (60 min incubation). Current results have shown that our essential oil could be used as a natural alternative to chemical preservatives in the food industry as well as the pharmaceutical industry.

Keywords: *Salvia officinalis, essential oil, camphor, S. aureus, E. coli, antioxydant*

LEMON ESSENTIAL OIL: MOLECULAR DOCKING ANALYSIS AND INVESTIGATION OF THE ANTIBACTERIAL AND ANTIOXIDANT ACTIVITIES

Vesna Antunović[1*], Željka Marjanović Balaban[2], Aleksandra Šmitran[3], Žarko Gagić[1], Nebojša Kladar[4], Vesna Gojković Cvjetković[5]

*[1]University of Banja Luka, Faculty of Medicine, Department of Pharmacy, Bulevar vojvode Petra Bojovića 1A, Banja Luka, Bosnia and Herzegovina, vesna.antunovic@med.unibl.org**
[2]University of Banja Luka, Faculty of Forestry, Bulevar vojvode Petra Bojovića 1A, Banja Luka, Bosnia and Herzegovina
[3]University of Banja Luka, Faculty of Medicine, Department of Microbiology and Immunology, Save Mrkalja 14, Banja Luka, Bosnia and Herzegovina
[4]University of Novi Sad, Faculty of Medicine, Department of Pharmacy, Hajduk Veljkova 3, Novi Sad, Serbia
[5]University of East Sarajevo, Faculty of Technology, Department of Food Technology, Karakaj 34a, Zvornik, Bosnia and Herzegovina

Abstract

Lemon essential oil is widely used in both commercial and domestic products. It consists of a mixture of volatile liposoluble compounds responsible for its characteristic fragrance and bioactive properties such as antimicrobial, anti-inflammatory and antioxidant activity. The importance of lemon essential oil is even more significant when considering the increasing interest in natural products that offer positive effects on human health. In this study, lemon grown domestically in the area of Mostar, in the south of Bosnia and Herzegovina, was used. The essential oil was extracted from the peel using the hydrodistillation method in a Clevenger apparatus, which is completely environmentally safe. The composition of the resulting essential oil was analyzed by gas chromatography coupled with mass spectrometry (GC-MS). GC-MS identified the presence of 18 constituents, of which the most abundant components in lemon essential oil were monoterpene olefins with a content of 95,97%. D-limonene was the main component, with a content of 63,48%, followed by β-pinene and γ-terpinene with content of 13,3% and 10,42% respectively. The antimicrobial activity of the essential oil was tested, demonstrating effectiveness against Staphylococcus aureus with a clear inhibitory zone in a diameter of 21 mm, which is considered as bacterial sensitivity to the testing substance. Molecular docking analysis revealed that all three principal compounds were able to bind to the DNA gyrase enzyme. Among them, d-limonene exhibited the lowest binding energy (-5.9 kcal/mol), which was comparable to that of ciprofloxacin (-5.9 kcal/mol), a well-known DNA gyrase inhibitor. The lemon essential oil also exhibited significant DPPH radical scavenging activity, highlighting its potential as an antioxidant. The results indicate that both the concentration and incubation time affect the antioxidant capacity of the essential oil. Our study results indicate that the antioxidant activity of lemon essential oil increases as the concentration rises, both after 20 minutes and 60 minutes of incubation. At the highest concentration of 150 mg/mL, LEO had a good DPPH free radical scavenging rate (76.0% sfor 20 min incubation time; 82.1% for 60 min incubation time).

Keywords: *Essential oil, Limonene, Molecular docking, S. aureus, Antioxidant*

GLYCERYL STEARATE CITRATE: NEW MODERN COSMETIC EMULSIFIER

Stevan Blagojević[1*], Ljubica Vasiljević[2], Ana Mitrović[3], Hadi Waissi[1]

*[1]Institute of General and Physical Chemistry, Studentski trg 12/V, Belgrade, Serbia, sblagojevic@iofh.bg.ac.rs**
[2]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Hercegovina,
[3] Cosmopharm, Zrenjaninski put 120, Belgrade, Serbia

Abstract

Emulsifiers play a crucial role in modern cosmetic formulations, ensuring stability and enhancing the sensory properties of emulsions. Glyceryl Stearate Citrate (GSC) is a novel, naturally derived, biodegradable, and mild anionic emulsifier that has gained attention due to its excellent biocompatibility and multifunctionality. It is synthesized through the esterification of glyceryl stearate with citric acid, resulting in a molecule that offers both emulsifying and conditioning properties. This study provides a comprehensive analysis of the physicochemical properties, mechanism of action, and benefits of Glyceryl Stearate Citrate in cosmetic formulations. Compared to traditional emulsifiers, GSC exhibits superior stability over a broad pH range, enhanced compatibility with active ingredients, and improved skin tolerance. Furthermore, due to its mildness, it is suitable for sensitive skin and baby care products. The research also highlights the eco-friendly aspect of GSC, as it is derived from renewable plant sources and is readily biodegradable, aligning with the current trend of sustainable cosmetic ingredients. Its ability to create light, non-greasy emulsions with a soft skin feel makes it highly desirable in formulations for facial creams, sunscreens, serums, and natural cosmetics.
In this study, the stability, viscosity, and sensory attributes of emulsions containing Glyceryl Stearate Citrate were evaluated. Results indicate that emulsions formulated with GSC demonstrate excellent stability even under stress conditions, such as varying temperatures and mechanical stress. Additionally, its synergy with other natural emulsifiers and co-emulsifiers enhances the stability and texture of final formulations. The findings of this study confirm that Glyceryl Stearate Citrate represents an advanced, multifunctional emulsifier that meets the growing demand for safe, effective, and environmentally sustainable ingredients. Its versatility and mild nature make it an essential component in modern cosmetic formulations, replacing traditional synthetic emulsifiers with more sustainable alternatives.

Keywords: *Glyceryl Stearate Citrate, emulsifier, natural cosmetics, stability, biodegradable, skincare formulations.*

SYNTHESIS AND CHARACTERIZATION OF NEW AZAMACROCYCLIC BINUCLEAR CU(II) COMPLEX

Mirjana Antonijević Nikolić[1], Branka Dražić[2]*, Slađana Tanasković[2]

[1]*Academy of Applied Studies Šabac, Department for Medical, business and technological studies, Hajduk Veljkova 10, Šabac, Serbia;*
[2]*University of Belgrade, Faculty of Pharmacy, Department of General and Inorganic Chemistry, Vojvode Stepe 450, Belgrade, Serbia; bdrazic@pharmacy.bg.ac.rs**

Abstract

The new mixed ligand complex of Cu(II) with octaazamacrocyclic ligand N,N',N'',N'''- tetrakis(2-pyridylmethyl)-1,4,8,11-tetraazacyclotetradecane (tpmc) and amino acid L-norleucine was synthesized and characterized by elemental analysis, conductivity data, infrared and electronic spectra. New complex is binuclear with the formula [Cu_2 (norleu) tpmc] (ClO_4)$_4$. In this complex, the octaazamacrocyclic ligand tpmc acts as a polydentate ligand coordinated through four N atoms for each Cu(II), whereas the amino acid coordinated through the carboxylate group. Both of the Cu(II) are coordinated with two pyridyl and two cyclam nitrogens and bridged with –N–(CH_2)$_3$–N–portions of the cyclam ring and oxygen atoms of L-norleucine.

Keywords: *Cu(II) complexes, octaazamacrocycle, L-aminoacids, L-norleucine*

ANALYSIS OF ELEMENTS IN DANDELION ROOTS SAMPLES COLLECTED FROM THE TERRITORY OF WESTERN SERBIA

Kosana Popović[1], Jelena Đuričić-Milanković[1], Mirjana Antonijević-Nikolić[1], Bojana Vučetić[1], Dragan Ranković[2], Branka Dražić[3]*, Slađana Tanasković[3]

[1]Academy of Applied Studies Šabac, Department of Medical and Business-Technological Studies, Šabac, Serbia
[2] University of Belgrade, Faculty of Physical Chemistry, Belgrade, Serbia
[3] University of Belgrade, Faculty of Pharmacy, Belgrade, Serbia,
*bdrazic@pharmacy.bg.ac.rs**

Abstract

The World Health Organization (WHO) estimates that around 70–80% of the world's population relies on non-conventional medications, most of which are derived from plant-based medicines. Dandelion (Taraxacum officinale) is a widely used medicinal plant in traditional medicine. In recent years, numerous studies have been conducted to improve the understanding of its medicinal and therapeutic properties, as well as its potential for practical clinical applications. Dandelion, belonging to the Asteraceae family, is a pharmacopeial and edible plant. In many European countries, it is a common weed found in fallow fields, along roadsides, in meadows, and on lawns. The pharmacopeial raw materials include the roots of dandelion (Taraxaci radix), the herba, and ~~also~~the flowers.The root of dandelion contains numerous beneficial compounds and elements, but also those that may be harmful to human health.

In this study, eight elements (Ti, Al, Li, Co, As, Mo, Sb, Tl) were determined in the roots of dandelion. During the autumn of 2022, dandelion root samples were collected from nine locations in the area of the municipality of Ljubovija, in western Serbia.Samples were prepared ~~by~~using dry digestion in triplicate, and the ash was dissolved in 6M HCl,followed by dissolution in 0.1M HNO_3. The content of the elements in the dandelion roots was determined using inductively coupled plasma optical emission spectroscopy (ICP-OES). The content of Ti, Al, Li and Co in the roots were found to be in the ranges of 3669.0±1223.5-20673.0± 4064.3, 128.7±5.7-1046.3±110.2, 1.2±0.4-2.7±1.4 and 0.2±0.0-1.0±0.0 mg/kg dry weight, respectively.The content of elements As, Mo, Sb, and Tl were below the detection limit.

Keywords: *Medical plant, Dandelion root, Elements, Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES).*

RAPID FUNGAL PHYTO-PATHOGEN IDENTIFICATION BY FOURIER-TRANSFORM INFRARED (FTIR) MICROSCOPY

Mahmoud Huleihel[1*], Vitaly Erukhimovitch[1]

*[1]Ben-Gurion University of the Negev, Faculty of Health Sciences, Department of Microbiology, Immunology and Genetics, Beer Sheva, Israel, mahmoudh@bgu.ac.il**

Abstract

Fungal pathogens are involved in serious damage to a wide range of crops, causing significant negative impacts on the economy. Early detection and identification of phytopathogens are crucial for for effective prevention and treatment strategies. Currently, fungal identification relies on classic microbiological, biochemical, immunological, and molecular methods. However, these methods are often time-consuming, lack specificity and ineffective for screening a large number of samples. Our study proved the potential of FTIR microscopy as a sensitive and effective method for detecting and distinguishing between various fungal genera.

Keywords: *fungal pathogens, FTIR microscopy, spectral characteristics*

EFFICIENT PROCEDURE FOR FUNGAL INFECTED POTATOES USING FTIR MICROSCOPY

Vitaly Erukhimovitch[1*], Mahmoud Huleihel[1]

[1]*Ben-Gurion University of the Negev, Faculty of Health Sciences, Beer Sheva, Israel, evitaly100@gmail.com**

Abstract

Phytopathogens are responsible for severe plant diseases, and may cause serious problems in food production. Thus, early identification of these fungal pathogens plays a crucial role in devising effective control strategies. Currently, available methods for identifying fungi are often time-consuming and lack specificity. Fourier-transform infrared (FTIR) microscopy is considered a sensitive method for detecting molecular changes in cells. Due to the high similarity between spectra of different fungal pathogen species, this method becomes paramount to enhance fungal discrimination in potatoes. We evaluated three potential procedures for preparing pathogen samples for examination using FTIR microscopy. Our results show that direct preparation of fungal samples from liquid growth media is the optimal method for FTIR microscopy examinations, offering improved results in the discrimination of potato fungal species.

Keywords: *FTIR microscopy, phytopathogens, spectral characteristics, fungal detection, agar.*

METHODS OF THE ZONAL MODEL APPLICATION IN NUMERICAL SIMULATIONS

Nenad Crnomarković[1*]

[1] *University of Belgrade, VINČA Institute of Nuclear Sciences-National Institute of the Republic of Serbia, Mike Petrovića Alasa 12-14, Belgrade, Serbia, ncrni@vin.bg.ac.rs**

Abstract

The radiative models used in the numerical simulations of the pulverized coal-fired furnaces can be divided into flux and zonal models. For the zonal models, furnace volume and walls are divided into volume and surface zones. For the calculations of the heat exchange, the direct and total exchange areas for each pair of the zones are needed. The problem with the application of the zonal model is inability to change the radiative properties during the iterative process of calculation. This paper describes the recent attempts to allow for the variation of the wall emissivities. Three models are described: temporary correction of the total exchange areas (TCTEA), repeated run of the numerical simulation (RRNS), and current correction of the total exchange areas (CCTEA). In the TCTEA model, the new values of the surface emissivities are found on the basis of the wall temperatures at the end of the numerical simulation and new set of the total exchange areas is determined. Three or four numerical simulations are needed to reach the convergent solution. All other variables start from the values determined by the previous simulation. The RRNS model is similar to the TCTEA model, with the exception that thermo-fluid variables start from the initial values. In the CCTEA model, the total exchange areas are modified as the calculation proceeds, according to the current values of the surface emissivities and summation principle. Only one numerical simulation is needed to reach the convergent solution.

Keywords: *Pulverized coal, furnace, zonal model, numerical simulation, radiative transfer, surface emissivities.*

AN OVERVIEW OF CERTIFIED ISO 45001 OH&S SYSTEMS IN THE REGIONAL CONTEXT

Željko Đurić[1], Nataša Cvijanović[2], Mitar Perušić[3], Duško Kostić[3,4 *], Jelena Vuković[3], Nebojša Vasiljević[3]

[1]University of East Sarajevo, Production and Management Faculty, Vojvode Stepe Stepanovića bb, Trebinje, Republic of Srpska, Bosnia and Herzegovina
[2]University of East Sarajevo, Faculty of Education, Semberskih ratara bb, Bijeljina, Republic of Srpska, Bosnia and Herzegovina
[3]University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Republic of Srpska, Bosnia and Herzegovina
*[4]IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Intzestr. 1, Aachen, Germany, DKostic@metallurgie.rwth-aachen.de**

Abstract

Occupational Health and Safety (OH&S) and other management systems are crucial in enhancing the operational activities of organizations in regional countries improving their public image and ensuring safety. Despite the evident advantages, the practical implementation and integration of these systems frequently present substantial challenges. These challenges can significantly influence an organization's decision to set up and certify integrated or particular management systems. This study provides a comprehensive analysis of the general concept, current status, and quantitative evaluation of organizations that have implemented certified OH&S management systems within the region. The analysis utilizes the most recent data released by the International Organization for Standardization (ISO), which includes wider statistics on the number, types, and trends of certified systems in the region. Based on this analysis, the paper offers well-informed observations, conclusions, and recommendations aimed at improving the current state and general measures to enhance OH&S in the regional context.

Keywords: *Certification, Management, Occupational Health and Safety (OH&S).*

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