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Poštovane kolege i sudionici 20. Ružičkinih dana,

s velikim zadovoljstvom Vas pozdravljamo i zahvaljujemo na Vašemu sudjelovanju i doprinosu obimu i uspjehu Konferencije! Danas su Ružičkini dani sa stalnim sloganom „Danas znanost – sutra industrija“ dobro poznati znanstveni i stručni skup u području kemije, kemijskog inženjerstva i tehnologije, zaštite okoliša i srodnih tema kojemu se mnogi sudionici rado iznova vraćaju. Prednost su mu široka interdisciplinarnost pa pruža priliku susretanja kolega iz drugih i srodnih područja te dobivanje uvida u istraživanja u raznim znanstvenim granama.

Na Ružičkinim danima 2018. godine pod predsjedanjem prof. dr. sc. Srećka Tomasa svečano je obilježena 40. godišnjica održavanja Konferencije, uz izdavanje opsežne monografije, a ove godine obilježavamo 20. održavanje. Tom prigodom htjeli smo uvesti nova događanja, te ih jednim dijelom otvoriti i prema građanima Vukovara. Uz proširenje tradicionalnog Susreta mladih kemičara koji ove godine sadrži i stručni dio programa za nastavnike, po prvi put se održava i Susret laboratorijskih tehničara. Ružičkin rad i postignuća na istraživanju spolnih hormona potaknuli su nas na izradu izložbe Kremija osjećaja koja se bavi odabranim ljudskim hormonima, prikazuje njihove kemijske strukture i opisuje njihovo djelovanje na stručan i zanimljiv način. Dodatno, po prvi puta smo postavili izložbu posterskih priopćenja na novi način, te uobičajeno priredili i bogat društveni program – obilazak muzeja Vučedol, uz zajednički ručak Podravka – od srca srcu, te večeru u Vinogradarskoj kući Goldschmidt.

Veselimo se izlaganjima i druženju, i zahvaljujemo svim sponzorima i donatorima, pokroviteljima i podržavateljima, te svima uključenima u organizaciju i program 20. Ružičkinih dana!

Dajana Kučić Grgić

Vesna Ocelić Bulatović

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PLENARNA PREDAVANJA
PLENARY LECTURES

CAN COCOA INDUSTRY TRANSFORM FROM ECO-DESTRUCTIVE TO ECO-FRIENDLY?

Đurđica Ačkar, Ivana Lončarević, Veronika Barišić, Ivana Flanjak

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Cocoa industry is often called out for the linear type of economy, with severe impact on the environment. From the cocoa growing, which has been linked to the deforestation, esp. in West Africa, loss of wild life and abuse of human rights, to the chocolate production, which generates large amounts of by-products worldwide, cocoa and chocolate have become environmental and social issue under the Sustainable Cocoa Initiative, EU Deforestation Regulation, Fair Trade, UTZ etc.

EU is determined to make cocoa production and processing eco-friendly. Cocoa growers are demanded to be eco-friendly, deforestation-free, with reduced disposal of cocoa by-products in the environment, while preserving human rights. Cocoa importers, chocolate producers and sellers are obliged to maintain sustainability circle. Additionally, raising cocoa prices are driving chocolate producers to seek for solutions for better utilization of raw materials, including by-products of cocoa processing (cocoa shell and germ).

Scientific community is extensively seeking for solutions to make cocoa production and processing more sustainable. Some solutions are close to the industrial application, others are already in the industrial environment, while some still need additional research to prove their potential. This presentation will give an overview of current solutions and limitations with examples from our own research, along with some future directions.

Keywords: cocoa, by-products, circular economy, sustainability

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IMAGING MASS SPECTROMETRY

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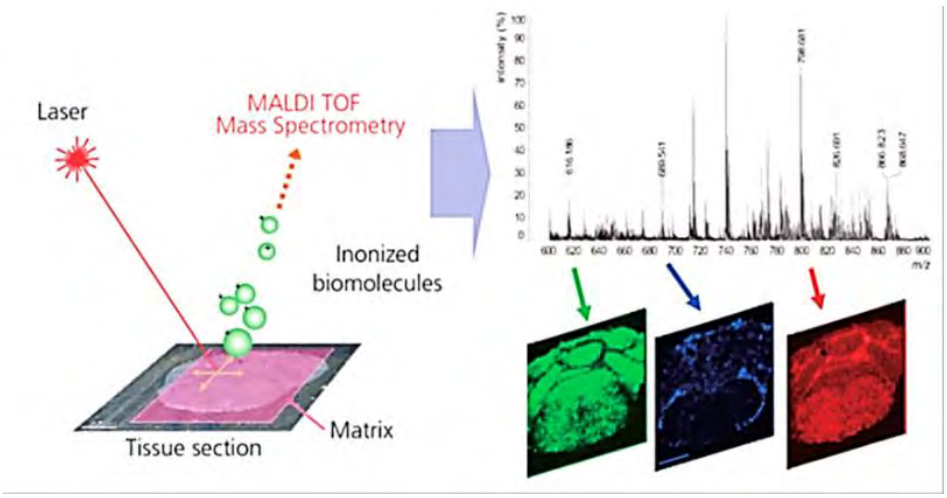
Developments of ionization sources enabled application of mass spectrometry for visualization of the solid-state samples' chemical composition. By pixel-wise mass spectra recording, the total-ion-current as well as the single-ion-current images characterized by micrometer or even submicrometer lateral resolution, may be created. Hence the name Imaging Mass Spectrometry (IMS). Depending on the instrumental settings, lateral distribution images of hundreds or even thousands of molecular ions may be constructed. Different classes of compounds have been analyzed using the IMS. By far, the greatest attention IMS has received in biomedicine where proteins and small metabolites are frequently analyzed by Matrix Assissted Laser Desorption-Ionization Time-of-Flight Imaging Mass Spectrometry (MALDI TOF IMS). The lecture will provide an overview of recent technical developments and biomedical applications of IMS.

Keywords: mass spectrometry, imaging, microscopy



NANOTECHNOLOGY IN MEDICINE: FROM BIOSENSORS TO SMARTER DRUG DELIVERY

Ljiljana Fruk

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Modern molecular science can be best described as a synergy of (bio)chemistry, molecular biology, engineering and lately, artificial intelligence, and it is paving a way to design of new materials with applications in precision medicine.

Remarkable advances have been made in design of bio-nano hybrids, which combine biomolecules and man-made nanostructures to overcome intrinsic differences between individual elements [1]. For example, antibody-coated gold nanoparticles have been used in numerous commercial biosensors, including lateral flow diagnostic tests for viral infections, while lipid nanocarriers have been extensively employed for delivery of mRNA and preparation of new generation of vaccines. As our technology evolves, it changes the way we perceive the diagnostics and treatment of diseases, moving towards more holistic and individualized approaches.

In this talk, we will have a look at the design principles and biomedical applications of bio-nano hybrids, in particular in development of *in vivo* detection systems for ageing cells [2] and early detection of cancer [3] as well as in drug delivery [4]. We will also explore what the future holds for the field of biomedical nanomaterials.

Keywords: nanotechnology, biosensors, drug delivery, precision medicine

[1] Lj. Fruk, A. Kerbs, Bionanotechnology: concepts and applications, Cambridge University Press, 2021.
[2] Baker et al., *Angew. Chem.* 63 (2024), e202404885.
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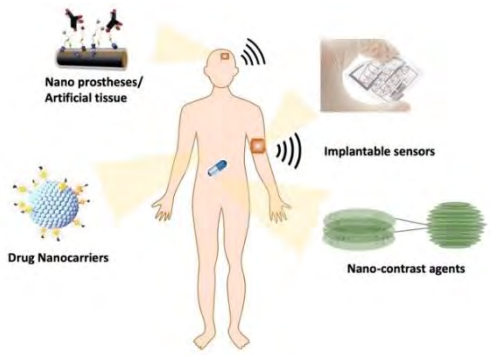

BALANCE OF ELECTROCATALYSIS AND CATALYSIS CAN ENABLE ENERGY-EFFICIENT CHEMICAL REACTIONS AT MILDER CONDITIONS

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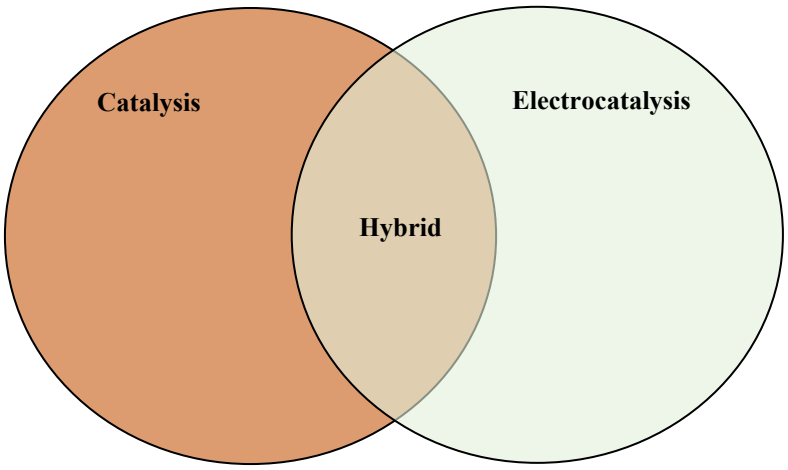
In this lecture I will in a very simple way cover the energy efficiency calculations, and how these can be performed for some of the chemical reactions that are run at industrial level. Then I will cover the basic thermodynamics (Gibbs free energy, Enthalpy and Entropy) of the multistep chemical reactions, specifically focusing on nitrogen and nitric oxide reduction, explaining differences between catalysis and electrocatalysis, particularly in terms of energy efficiency. I will explain how Gibbs free and activation energy of each step are related to the electrochemical cell potential and overpotential, from the aspect of DFT calculations other researchers performed. Then I will explain how the chemical energy of the reductant can be untapped during the electrocatalysis process. Then we relate the theory to some of the preliminary experimental work from our lab obtained during the EU project ORACLE, where we performed NO reduction with hydrogen catalytically to ammonia, at room temperature. But we also tried to run electrocatalysis on top of the catalysis, thus untapping the chemical energy of hydrogen while affecting the selectivity electrochemically. While this lecture does not present the improved selectivity of the reaction to ammonia, it does show, what we believe to be among the first attempts to run the reaction "hybrid", at room temperature.

Keywords: electrocatalysis, energy-efficient chemical reactions, catalysis, ammonia



SCALABLE FABRICATION OF POTENTIOMETRIC SENSORS: TOWARDS FULLY PRINTED ION-SELECTIVE ELECTRODES

Petar Kassal, Sara Krivačić, Marko Zubak, Željka Boček
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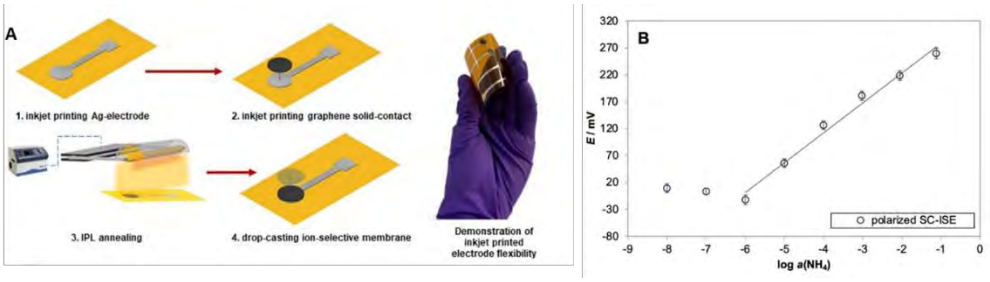
Due to several advantages, including ease of use, greater miniaturization, production scalability, and reduced cost, solid-contact ion-selective electrodes (ISEs) are dominating the field of potentiometric sensing. 2D designs and flexible formats are being implemented to enable new application scenarios and mass production strategies are being sought out to facilitate distributed sensing on a large scale [1]. Various technologies from the printed electronics industry can be utilized in the fabrication of solid-state ISEs. The potential and challenges of using screen printing, inkjet printing and intense pulsed light will be highlighted in this talk. Secondly, a flexible inkjet printed ammonium ISE will be presented [2]. The solid contact of the ISE is based on inkjet-printable mechanically exfoliated melamine-intercalated graphene nanosheets [3]. The developed ISE exhibits a linear response over 6 orders of magnitude, an LOD of 0.88 µM and was successfully used for determination of ammonium concentration in complex samples, such as landfill leachate water. However, the conventional ion-selective membrane has unsuitable physicochemical properties for inkjet printing. In the last part of the talk, optimization of the ion selective membrane composition and its deposition with an automated fluid dispensing system (spotter) will be presented.

Keywords: potentiometric sensors, solid-contact ion-selective electrodes, inkjet printing, intense pulsed light

[1] Y. Shao, Y. Ying, J. Ping, *Chem. Soc. Rev.* 49 (2020) 4405-4465.
[2] S. Krivačić, Ž. Boček, M. Zubak, V. Kojić, P. Kassal, *Talanta* 279 (2024) 126614.
[3] M. Kralj, S. Krivačić, I. Ivanišević et al., *Nanomaterials* 12 (2022) 2936.



Ammonium ISE fabrication via inkjet printing (A) and the ISE response (B)

THE BACKGROUND FOR DEVELOPING ENERGY AUTONOMOUS GAS NANOSENSOR

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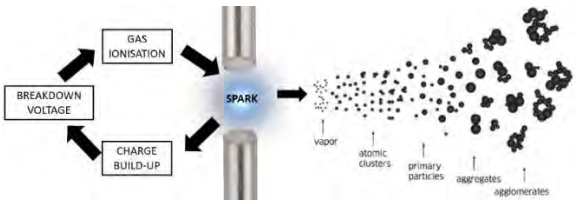
Developing new constituent nanomaterials for advanced devices is a challenging task that heavily relies on achieving the right chemical composition to optimize material performance. While chemical composition is fundamental, advancements in morphology can further enhance material properties. Moreover, numerous instances demonstrate the advantages of additionally organized material structures. This nanostructuring principle can also be applied to functional nanomaterials, underlining all mentioned factors are crucial for demonstrating showcase performances. For instance, better gas sensors rely on increasing the interface but not at the cost of chemical interference.

Moreover, better gas sensors rely on energy autonomous operation via integration of energy conversion or storage segments but not at the cost of sensing efficiency. Approaches from the pool of chemical or physical depositions have been employed to fabricate advanced materials through variety of top-down processing. Commonly these methods face limitations in terms of complexity, cost and flexibility. As a solution to these challenges spark plasma ablation deposition (SPAD) is proposed. SPAD offers a versatile, cost-effective, environmentally and user-friendly method of nanomaterial preparation and deposition under almost ambient conditions. SPAD allows for the use of pure or alloy electrodes, expanding the range of compositions that can be created. SPAD involves sparking electrodes into a plasma cloud, leading to the rapid condensation and formation of atomic clusters that coalesce into nanoparticles suitable for deposition through variety of reactors and nozzles. By inducing coagulation between multiple materials, a homogeneous nanoscale mixture of precursor metals can be obtained in protective atmosphere or mixed metal oxides in reactive atmosphere.

This approach presents an innovative bottom-up strategy that holds promise for designing new materials. SPAD envelope includes nanoparticles and thin films, metals and metal oxides, crystalline and amorphous products. Therefore, provided examples will illustrate the impact of factors such as oxygen content and geometrical considerations on material structure and properties, highlighting their utility in gas sensors and other advanced systems.

Keywords: nanomaterials, nanostructuring, nanoparticles, gas sensors, smart materials



DETERMINATION OF INORGANIC IONS BY POTENTIOMETRIC SENSORS MODIFIED WITH DIFFERENT METAL OXIDES AND OXYHYDROXIDES NANOPARTICLES

Ante Prkić[1], Ivana Mitar[2], Andrea Paut[1], Karmela Zanki Kulazo[1], Ita Hajdin[1], Kristian Nakić[2]

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Ion-selective electrodes represent electrochemical sensor able measuring ion activity in various samples, and often are modified with different kinds of metal nanomaterials. There will be presented two solid-state ion-selective electrodes enriched with microwave synthesized hematite, magnetite, boehmite or aluminium oxide nanoparticles. Nanoparticles were characterized with FTIR and SEM with EDS. The first one is based on $FePO_4$: Ag_2S : PTFE = 1:1:2 and the second one is based on $BaSO_4$: Ag_2S : PTFE = 1:1:2 with addition of (0.25-1)% nanoparticles, respectively. The membrane containing hematite nanoparticles in 0.25% ratio had the most significant impact on ferric cation determination in range from $1.2 \cdot 10^{-6}$ to 10^{-2} mol L^{-1} with slope of -19.8 mV per decade, almost identical with theoretical Nernstian slope for trivalent cations and R^2=0.9925. High arithmetic middle of recovery values (102.8%) in ferric determination in standard solution confirmed wide applicability [1]. On the other hand, the membrane containing 0.6% magnetite nanoparticles positively affected the linear response range for sulfate anions. The potentiometric sensor exhibited a linear change of potential with a slope of 27.7 mV dec^{-1}, which is very close to the theoretical Nernstian value (29.6 mV dec^{-1}), with a regression coefficient of 0.9970 in the concentration range of $4.88 \cdot 10^{-5}$ mol L^{-1} - $1.00 \cdot 10^{-2}$ mol L^{-1}, and LOD of $4.34 \cdot 10^{-5}$ mol L^{-1}. It is noteworthy to mention these potentiometric sensors for sulfates showed no response to barium ions even at high concentrations ($\geq 1.00 \cdot 10^{-3}$ mol L^{-1}).

Keywords: ion-selective electrode, potentiometry, iron, sulfate, iron oxide nanoparticles

[1] A. Paut, A. Prkić, I. Mitar, P. Bošković, D. Jozić, M. Jakić, T. Vukušić, *Sensors* 21 (2021) 1612.

This research was supported by funding through grant number UIP-2017-05-6282 provided by Croatian Science Foundation.

RESEARCH, INVENTION, DEVELOPMENT AND COMMERCIALIZATION OF NOVEL ADVANCED FOOD PROCESSING TECHNOLOGIES: FOUR NEW FOOD AND BEVERAGE PROCESSING FACILITIES, IMPLEMENTED EQUIPMENT, DEVELOPED PRODUCTS, PROCESSING AND PACKAGING CAPACITIES AND FORMAS

Josip Simunovic

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Scientific and engineering bases for the invention, development and commercialization of a series of patented advanced food, beverage and biomaterial processing technologies will be presented. Particularly, work on continuous flow microwave processing technologies invented and developed by our teams at North Carolina State University will be specifically discussed.

Four different industrial processing facilities where commercialization of these inventions has been implemented will be described, with the implemented processing and packaging equipment used, as well as the product types introduced to the business and consumer marketplaces, with a special focus on products from sweetpotatoes and ingredients for further processing based on sweetpotatoes.

North Carolina is the largest producer of this crop in the United States with over 60%, while the largest producers in the world are located in Africa where one of our installations has been in production for 2 years, with several others under construction and pending. Microwave processing enables the shelf stability of these products for 12-18 months at ambient temperatures, requiring no refrigeration of the final packages but keeping the nutritional and flavor quality.

New development plans and current R&D efforts will be presented, related to the technology, new capabilities and new bioactive target materials for studies and commercial introduction.

Keywords: food processing technologies, continuous flow microwave processing, sweetpotatoes

MANAGEMENT OF SEWAGE SLUDGE IN THE SCOPE OF CIRCULAR ECONOMY

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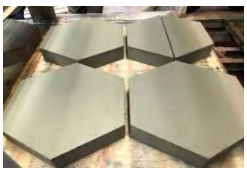
Sewage sludge is a main by-product of wastewater treatment plants (WWTPs), which its management is expensive and environmentally as well as socially quite sensitive. Based on the review and description of a number of technical and technological solutions for sludge management used in today's worldwide practice, it is concluded that the problem of sludge management is not of a technical nature, but rather a consequence of different approaches that are conditioned by the economic, environmental and social circumstances of particular countries or regions. Due to significant economic, ecological, and social factors, the scientific and professional communities worldwide have not yet reached a consensus on finding an optimal solution. This paper will present global trends in sludge management, with a particular focus on EU countries. The methodology that guides decision-makers towards selecting the optimal sludge management solution will be described. The results of previous scientific research conducted in Croatia in the domain of sludge management within the framework of the circular economy will be presented separately. The results related to the incorporation of sludge into concrete and bricks will be described. Two pilot projects were conducted in collaboration with industry (concrete and brick manufacturers), and the basic characteristics of innovative concrete and brick products with incorporated sludge will be described. The obtained results indicate the justified replacement of up to 10% of cement (as the most expensive component in concrete production) with ash derived from the thermal treatment of sludge. Additionally, the justified replacement of up to 10% of clay (as the main natural resource in brick production) with sewage sludge ash has been proven. The obtained characteristics (physical, mechanical, chemical, ecological) of the innovative concrete and bricks can be assessed as similar to the reference products without the addition of sludge/ash.

Keywords: sewage sludge, management, circular economy, concrete, brick, BRAVOBRICK

[1] D. Nakić, D. Vouk, S. Hozmec, N. Štirmer, *Hrv. Vode* (2018).
[2] A. Bubalo, D. Vouk, N. Stirmer, K. Nad, *Sustainability* (2021).



USMENA PRIOPĆENJA
ORAL PRESENTATIONS

SYNTHESIS OF NOVEL CONDUCTIVE AND STRETCHABLE COPOLYMERS BASED ON POLY (3,4-ETHYLENEDIOXYTHIOPHENE)

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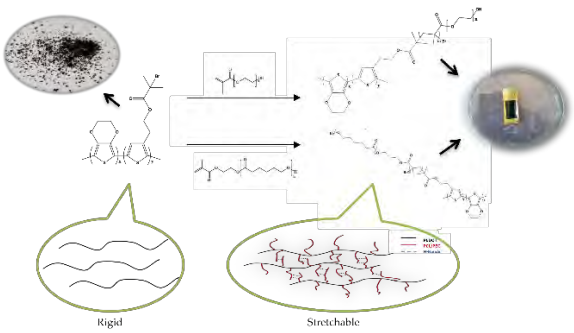
University of Zagreb Faculty of Chemical Engineering and Technology, Marulićev trg 19, 10000 Zagreb

This work gives an insight in one of many ways of tailoring the properties of conductive polymers in order to obtain novel molecules for the use in wearable electronics field. Conductive polymers are a great substitute for the inorganic conductors and semiconductors because of their lightweight, great stability, ease of preparation and possibility of tailoring the properties. Poly(3,4-ethylenedioxythiophene) (PEDOT) is one of the most promising conductive polymers in various fields, but it usually lacks mechanical properties such as stretchability. With this in mind, we have found a simple way to obtain polymers with appropriate conductive properties and additional stretchability. In the first step, a PEDOT derivative with a special bromoalkyl group is synthesized, which serves as a site for the further synthesis steps. The second step involves atom transfer radical polymerization (ATRP) as a tool for grafting softer polymers, such as poly(ethylene glycol) (PEG) and polycaprolactone (PCl) onto the conjugated PEDOT backbone to obtain stretchable, conductive polymers. After investigating the thermal properties and molecular structure, the resulting samples are additionally inkjet printed onto the stretchable substrate. Finally, the printed samples are characterized using different techniques to investigate the stability and structure of the produced samples as well as the correlation between stretchability and conductivity.

Keywords: conductive polymers, ATRP, PEDOT, inkjet printing



KEMIJSKE OSOBINE GEOTERMALNE VODE KRAPINSKIH TOPLICA
CHEMICAL PROPERTIES OF GEOTHERMAL WATER OF KRAPINSKE SPA

Dragana Dogančić, Anita Ptiček Siročić, Maja Jurenec, Josip Stojak
Sveučilište u Zagrebu Geotehnički fakultet, Hallerova aleja 7, 42000 Varaždin

Osnovni prirodni resurs na kojem Općina Krapinske Toplice temelji svoj razvoj su izvori geotermalne vode koja izvire u uskoj dolini potoka Topličine na tri jača i nekoliko manjih izvora. Temperatura vode je oko 40 °C što vodu čini hipertermalnom, a količina istjecanja je konstantna i iznosi oko 81,6 L/s. Voda prema ionskom sastavu voda pripada CaMg-HCO_3 facijesu te joj se kemijski sastav nije mijenjao godinama, što ukazuje na konstantan režim istjecanja geotermalne vode na izvorištima. Kemijski sastav geotermalnih fluida je rezultat otapanja i alteracije primarnih i taloženja sekundarnih minerala, a te reakcije ponajprije ovise o temperaturi, tlaku i sastavu stijena. Uzorkovanjem su obuhvaćene Jakobova i Pučka kupelj, potok Topličina te je uzet i uzorak s pumpe na Pučkoj kupelji. U ispitivanim uzorcima termalne vode vrijednosti ispitivanih parametara su unutar maksimalnih dopuštenih koncentracija prema *Pravilniku o parametrima sukladnosti, metodama analiza i monitorinzima vode namijenjene za ljudsku potrošnju*. Budući da se dio vode izlijeva u prirodni vodotok (potok Topličina) bitno je da otpadne termalne vode imaju niže vrijednosti od onih propisanih *Pravilnikom o graničnim vrijednostima emisija otpadnih voda* što je ovim ispitivanjima i dokazano.

Ključne riječi: geotermalna voda, Krapinske Toplice, geokemija vode

CONDUCTIVE PEDOT-THERMOPLASTIC ELASTOMER FILMS FOR STRETCHABLE ELECTRONICS

Lucija Fiket[1], Marin Božičević[1], Yuhka Uda[2], Xin Sun[2], Jadranka Travaš-Sejdić[2], Zvonimir Katančić[1]

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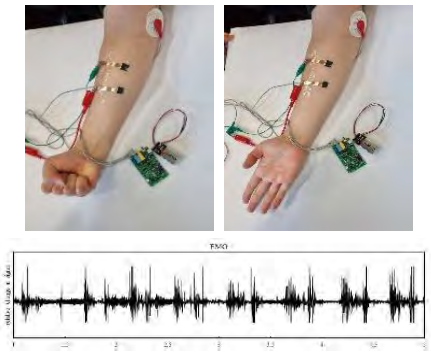
This research focuses on the synthesis and characterization of intrinsically stretchable and conductive composite films of poly(3,4-ethylenedioxythiophene) (PEDOT) and the thermoplastic elastomer sulfonated polystyrene-block-poly(ethylene-ran-butylene)-block-polystyrene (S-SEBS). The aim was to develop materials for applications in flexible electronics, in particular for the fabrication of simple sensors to evaluate their effectiveness in detecting biological signals in the real world. The synthesis of the macroinitiator PEDOT-Br was optimized by adjusting the proportions of S-SEBS. Poly(acrylate-urethane) chains were then grafted onto PEDOT-Br to produce a self-healing polymer. These materials exhibited an electrical conductivity of about 3 S/cm and a 60-70 % stretchability, meeting the requirements for wearable bioelectronic devices. These materials were validated by using them as electrodes in electromyogram (EMG) measurements on human skin. EMG tests showed significant changes in signal intensity compared to background noise during muscle contractions. This confirmed not only the practical functionality of the PEDOT-Br and grafted PEDOT-*g*-PAU materials as electrodes, but also their ability to record the electrical activity of muscles accurately. The clarity and consistency of EMG data obtained with these novel polymer films indicate their considerable potential for use in clinical and fitness settings where monitoring muscle activity is critical. Their ability to maintain performance under mechanical stress underscores their suitability for real-world applications in wearable technology.

Keywords: poly(3,4-ethylenedioxythiophene), thermoplastic elastomer, muscle activity monitoring



PRIMJENA INOVATIVNIH TEHNOLOGIJA U PROIZVODNJI DJEVIČANSKOG MASLINOVOG ULJA
THE INFLUENCE OF INNOVATIVE TECHNOLOGIES IN THE PRODUCTION OF VIRGIN OLIVE OIL

Katarina Filipan[1], Klara Kraljić[1], Maja Jukić Špika[2], Mirella Žanetić[2], Mia Ivanov[1], Tomislava Vukušić Pavičić[1], Višnja Stulić[1], Zoran Herceg[1], Marko Obranović[1], Sandra Balbino[1], Dubravka Škevin[1]

[1]*Sveučilište u Zagrebu Prehrambeno-biotehnološki fakultet, Pierottijeva 6, 10000 Zagreb*

[2]*Institut za jadranske kulture i melioraciju krša, Put Duilova 11, 21000 Split*

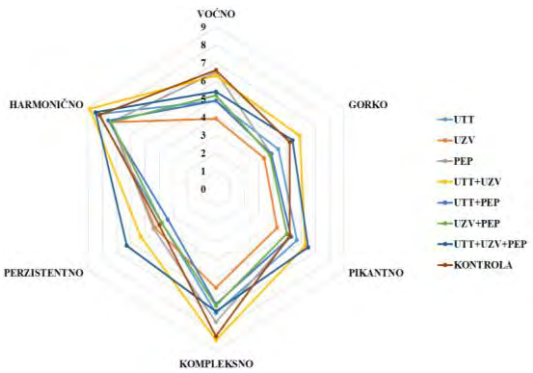
Cilj rada je bio istražiti utjecaj ubrzanog toplinskog tretmana (UTT – 19,5 °C), ultrazvuka (UZV - snaga ultrazvučne kupelji 576 W i trajanje 5 min), pulsirajućeg električnog polja (PEP - jakost električnog polja 2 kV/cm i trajanje 90 s) i njihovih kombinacija kao predtretmana miješenju i bez miješenja (BM) na iskorištenje proizvodnje (I), fenole (F) i senzorske karakteristike (SK) djevičanskog maslinovog ulja (DMU) autohtone hrvatske sorte levantinka. DMU su proizvedena centrifugalnom ekstrakcijom, F su određeni HPLC metodom, a SK IOC metodom. Rezultati pokazuju da sve kombinacije koje uključuju PEP dovode do povećanja I, dok je povećanje F zabilježeno jedino u uzorku UTT+UZV. Također, inovativne tehnologije i njihove kombinacije nisu narušile senzorsku kvalitetu DMU, a ispostavilo se da kombinacije tehnologija ne mogu zamijeniti miješenje.

Ključne riječi: djevičansko maslinovo ulje, fenoli, inovativne tehnologije, iskorištenje proizvodnje, senzorska analiza

Iskorištenje (%) i ukupni fenoli (mg/kg) DMU

UZORAK	I (%)	UF (mg/kg)
KONTROLA	9.16	411.20
UTT	8.77	370.18
UZV	9.77	308.94
PEP	9.17	346.72
UTT+UZV	9.1	431.03
UTT+PEP	9.86	368.43
UZV+PEP	9.74	345.05
UTT+UZV+PEP	9.63	378.43
UTT+UZV BM	1.77	321.55
UTT+PEP BM	3.78	332.48
UZV+PEP BM	1.81	335.03
UTT+UZV+PEP BM	3.05	342.97

Senzorske karakteristike DMU



IMPROVING CLAY PROPERTIES WITH COARSE-GRAINED PV GLASS

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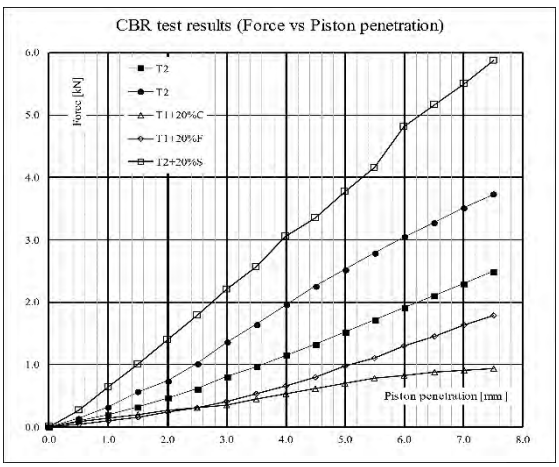
University of Zagreb Faculty of Geotechnical Engineering,
Hallerova aleja 7, 42000 Varaždin

This study explores the potential of using recycled waste glass, mainly from photovoltaic (PV) panels, as a substitute or additive for natural aggregates in geotechnical construction. Given the increasing production of PV glass, which is projected to rise from 24 million tons in 2024 to 105 million tons by 2032 [1], and the environmental and economic benefits of recycling, this research is timely and significant. The study investigates the geotechnical properties of low plasticity clay (CL) mixed with various types of crushed glass, including CRT screens, fluorescent lamps, and solar panels, with a 20% mass fraction of glass. Laboratory tests assessed parameters such as maximum dry density, optimum water content, California Bearing Ratio (CBR), and permeability. Results indicate that all soil-glass mixtures meet the Croatian General Technical Requirements [2] for road works, with the mixture containing solar panel glass showing particularly promising improvements in geotechnical properties. The findings suggest that recycling PV glass in construction meets environmental goals and enhances material performance, warranting further research into its application in infrastructure projects involving poor soil conditions.

Keywords: PhotoVoltaic glass, clay-glass mixture, clay properties improvement, coarse-grain

[1] https://www.sphericalinsights.com/press-release/solar-pv-glass-market [Accessed 20 May 2024].
[2] Croatian Institute of Civil Engineering, General Technical Requirements for Road Works, Sveučilišna tiskara d.o.o., Zagreb, 2001, str. 1–158.



ULTRASOUND-ASSISTED EXTRACTION FOR PHENOLIC COMPOUNDS EXTRACTION FROM SAFFRON (*C. sativus*) FLORAL BY-PRODUCTS

Valentina Masala[1], Stela Jokić[2], Krunoslav Aladić[2], Maja Molnar[2], Carlo Ignazio Giovanni Tuberoso[1]

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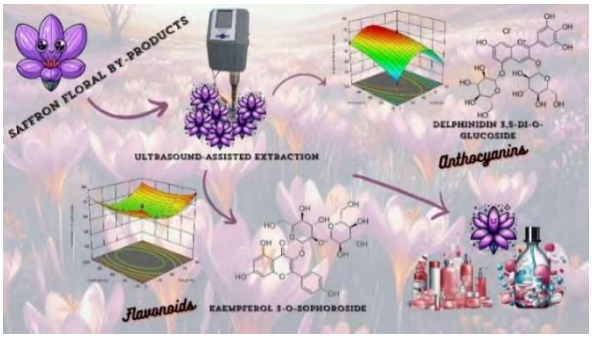
[2]*Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek*

This study evaluated the extraction of phenolic compounds from saffron (*Crocus sativus* L.) floral by-products using Ultrasound-Assisted Extraction (UAE) with sonotrode, with a focus on flavonoids and anthocyanins. Phenolic compounds were identified by (HR) LC-ESI-QTOF MS/MS analysis, and the quantitative analysis was performed with HPLC-PDA [1]. The Response Surface Methodology and the Box-Bunken Design were used to optimize the most important operating variables of the UAE using a sonotrode (solvent type, amplitude, impulse) to achieve the highest amount of the most abundant detected compounds (kaempferol 3-*O*-sophoroside and delphinidin 3,5-di-*O*-glucoside). The results suggest that the solvent EtOH: H_2O (50:50, *v/v*) was the best choice, showing a high amount for both anthocyanins and flavonoids (93.43 ± 4.67 mg/g of dry plant) and it was followed by 96% EtOH. As a result, UAE can be used to extract the beneficial chemicals from saffron flower by-products to be utilized in the cosmetic, pharmaceutical, and nutraceutical sectors, incorporating recycling and waste reduction.

Keywords: saffron, by-product, green extraction, response surface methodology

[1] K. A. Gil, S. Jokić, A.-M. Cikoš, M. Banožić, M. Jakovljević Kovač, A. Fais, C. I. G. Tuberoso, *Plants* 12 (2023) 1461.



AZITHROMYCIN MORPHOLOGY: COMPUTATIONAL PREDICTION AND EXPERIMENTAL VALIDATION

Ivana Mikulčić[1], Edi Topić[2], Ernest Meštrović[1]

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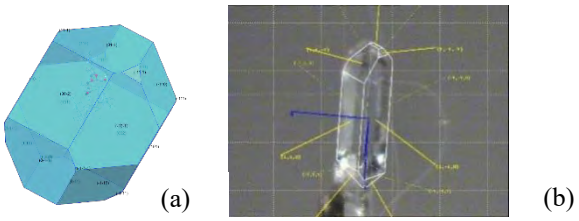
Azithromycin, widely known under the brand names Sumamed® and Zithromax®, is recognized for its efficacy in treating various bacterial infections. This study focuses on a detailed investigation of the morphology of azithromycin single crystals, which are equally important for the crystallization process in manufacturing as well as for the optimization of solid dosage form formulations. The crystalline structure of the active pharmaceutical ingredient (API) directly influences its stability, solubility, and bioactivity, which is well-known and widely accepted. In contrast, the understanding of the contributions arising from different morphologies of the same crystal structure is less known and explored.

In this study, advanced methods for predicting crystal morphology were applied, including the Bravais-Friedel-Donnay-Harker (BFDH) theory and attachment energy theory. These theories enable precise predictions of crystal shapes based on energetic interactions and crystal structure. The experimental part of the study includes the application of various crystallization methods.The crystal faces were indexed using X-ray diffraction, confirming the predictions obtained from theoretical models.The results obtained from the experimental methods correspond to the theoretical predictions, validating the applied models and methods. This demonstrates how detailed analysis and understanding of the morphology of azithromycin single crystals can significantly enhance the preparation process of APIs directed towards the desired morphology, which can be influenced if the relationship between crystal structure and crystal morphology is well understood.

Keywords: azithromycin, crystal morphology, crystal growth, energy attachment theory



(a) (b)

Calculated morphology (a) and observed (b) crystal faces of azithromycin dihydrate

MANGANESE DOPED α-ALUMINA RED PIGMENT

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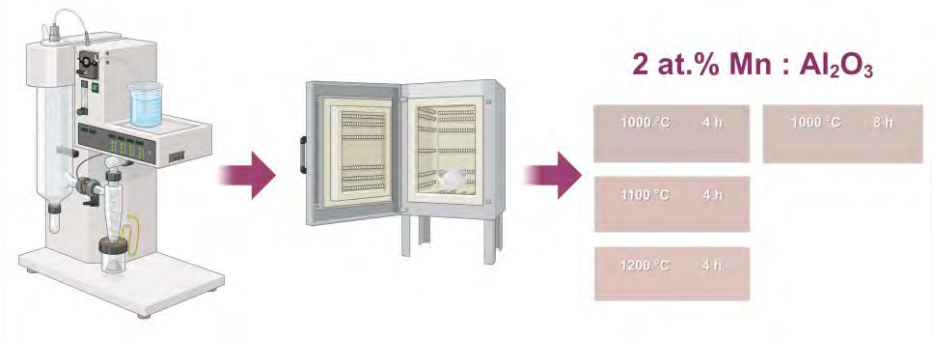
Manganese doped α-alumina is a well-known red pigment widely use in ceramic industry due to its high colour stability and temperature resistance [1]. In this work Mn doped alumina samples doped with 0, 2 and 4 at. % of Mn were prepared by the simple, cost-effective and industrially feasible spray drying method [2] and subsequently calcined at 700 °C for 4 hours. The still amorphous samples were thermally treated at 1000, 1100 and 1200 °C for 4 and 8 hours. Samples were analysed using X-ray diffraction analysis (XRD), Fourier transformed infrared spectroscopy (FTIR), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), differential thermal and thermogravimetric analysis (DTA-TGA) and UV-Vis diffuse reflectance spectroscopy (UV-Vis DRS). The XRD results indicate the presence of corundum and, in the case of Mn doped samples, small amounts of hausmannite and Mn_2AlO_4. According to DTA-TGA analysis, the corundum crystallization peak shifts towards lower temperatures with increasing manganese content in the samples. The lightness, redness and yellowness of the prepared pigments increase with temperature elevation and prolonged heat treatment duration.

Keywords: alumina, manganese, pigment, spray drying

[1] S. Wang, J. Yang, X. Ouyang, D. Han, *Adv. Mater. Res.* 250-253 (2011) 769.
[2] S. Kurajica, K. Mužina, A. Petračić, J. Teržan, F. Car, B. Likozar, K. Miloš, *J. Therm. Anal. Calorim.* (2024) online first.



DESIGN SIMULATION OF GREEN HYDROGEN PRODUCTION PROCESS

Marko Sejdić[1], Srečko Herceg[1], Nenad Bolf[1], Željka Ujević Andrijić[1], Ante Jukić[1], Danijel Krznar[2]

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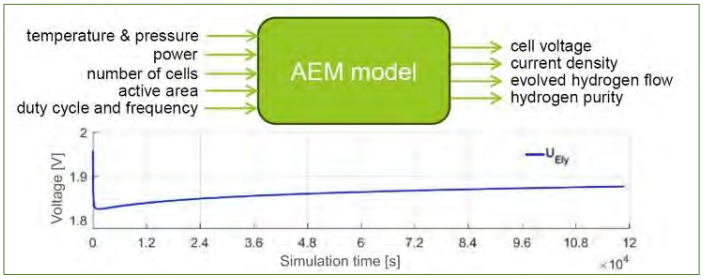
As a clean and sustainable source of energy, green hydrogen is proving to be a promising alternative to fossil fuels, showing considerable potential in the fight against climate change. Green hydrogen is predominantly generated through the electrolysis of water using electricity from renewable sources. The two main technologies for water electrolysis are alkaline (AE) and proton exchange membrane (PEM). Alkaline electrolysis faces issues primarily related to efficiency, gas purity, and maintenance. Although PEM electrolysis addresses these issues, it is costly due to the use of sensitive and expensive membranes and noble metal catalysts.

Recent research has focused on AEM (anion exchange membrane) electrolysis to facilitate the production of larger volumes of green hydrogen. AEM electrolysis offers several benefits compared to traditional methods: it utilizes catalysts that do not require noble metals, employs distilled water or a low-concentration alkaline solution, and features a simpler and cheaper membrane design. Despite ongoing advancements, there remains a significant need for research to develop stable AEM electrolyser components and improve energy efficiency.

Our work presents a design simulation of green hydrogen production process using AEM water electrolysis. By incorporating pulse-width modulation (PWM) to modulate the DC electrical signal, we identified the optimal process conditions for maximizing hydrogen production and efficiency. These conditions produced significantly improved results compared to scenarios without PWM. Based on the presented model, our research continues with an experimental design using lab-scaled setup of green hydrogen production process.

Keywords: green hydrogen, AEM water electrolysis, process modelling, PWM



INFLUENCE OF MULTIPLE MECHANICAL RECYCLING ON LEACHING OF ADDITIVES FROM MICROPLASTIC

Petra Soldo, Josipa Papac Zjačić, Zvonimir Katančić, Ana Lončarić Božić

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The increasing production and use of plastics leads to an increase in the amount of plastic waste that ends up in the environment due to improper disposal. When plastic waste is exposed to environmental conditions, it degrades and breaks down into microplastics (MP). Various additives used in the production of polymer materials, some of which are toxic, can leach out of microplastics.

Mechanical recycling has proven to be an effective method of reducing the amount of plastic waste. This technique allows plastics to be reused by processing the material into new products, reducing the need to produce new raw materials.

The aim of this work was to investigate the influence of multiple mechanical recycling on the release of additives from polypropylene (PP) microplastics. Multiple mechanical recycling was performed on polypropylene samples to which two types of antioxidants and a plasticizer were added. After each recycling cycle, samples were crushed to the size of microplastics and characterized by Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) to monitor changes in the properties of microplastics. Samples of microplastics were placed in water, and by monitoring biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC) and toxicity, the impact of multiple recycling on the release of additives into the environment was assessed.

Keywords: microplastics, mechanical recycling, leaching of additives, toxicity

PRIMJENA METODA STROJNOG UČENJA U KEMIJSKOM INŽENJERSTVU: TEORIJA I PRAKSA

APPLICATION OF MACHINE LEARNING METHODS IN CHEMICAL ENGINEERING: THEORY AND PRACTICE

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Strojno učenje u kemijskom inženjerstvu ima široku primjenu, kao što je predviđanje teško mjerljivih svojstava produkata u realnom vremenu, analiza velikih količina podataka, prediktivna dijagnostika procesne opreme, modeliranje kemijskih reakcija te praćenje i upravljanje kvalitetom. U doba digitalizacije, kada postrojenja i laboratoriji generiraju ogromne količine podataka, strojno učenje pruža alate za učinkovitu analizu i izvlačenje vrijednih informacija. Rad će obuhvatiti temeljna znanja o predobradi podataka i metodama strojnog učenja, s posebnim naglaskom na umjetne neuronske mreže. Autori će prenijeti stručno i znanstveno iskustvo kroz primjere iz rafinerijske i farmaceutske industrije te praćenja kvalitete zraka. Prikazat će se razvoj modela softverskih senzora za kontinuiranu procjenu svojstava proizvoda u svrhu zamjene skupih *on-line* analizatora, modele za praćenje nastajanja naslaga u izmjenjivačima topline, praćenje koncentracije otopine tijekom kristalizacije farmaceutskih tvari pomoću Ramanove spektroskopije, te predviđanje koncentracije lebdećih čestica u zraku i predikciju nastanka kokristala u farmaceutskoj industriji.

Ključne riječi: strojno učenje, neuronske mreže, softverski senzori, prediktivna dijagnostika

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KEMIJSKA ANALIZA I SINTEZA
CHEMICAL ANALYSIS AND SYNTHESIS

GREEN SYNTHESIS OF SILVER NANOPARTICLES USING GREEN TEA: CHARACTERIZATION AND ANTIBACTERIAL PROPERTIES

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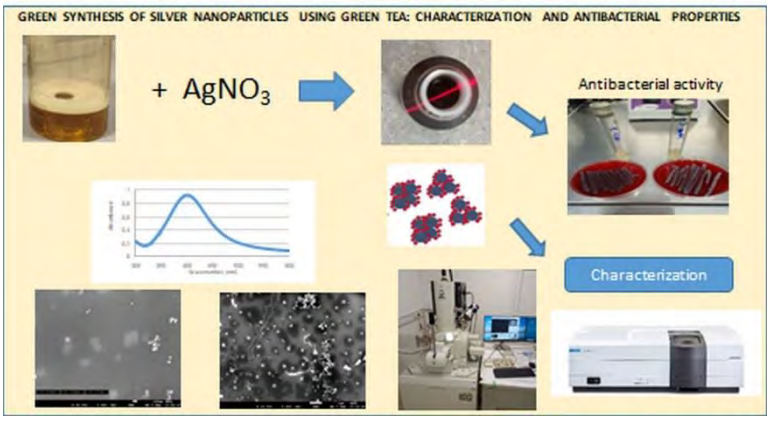
In this paper, silver nanoparticles were synthesized in an ecological way and without using organic or toxic solvents. The synthesis was carried out with green tea as reducing and stabilizing agent using 1 mmol dm^{-3} silver nitrate solution and distilled water as solvent. A considerable amount of catechins in green tea is involved in silver ion reduction. Catechins are flavanols related to catechins. The characterization of colloidal silver was performed by UV-Vis spectrophotometer, FTIR, DLS (Dynamic Light Scattering) and SEM (Scanning Electron Microscopy). UV-Vis spectrophotometry proved the presence of silver nanoparticles by the occurrence of surface plasmon resonance, while DLS and SEM analysis was used to evaluate the size and shape of the resulting silver nanoparticles and the uniformity of the resulting nanoparticle sample. The antibacterial efficacy of the silver nanoparticles was tested on the bacteria *Escherichia coli* NCTC 13216 and *Staphylococcus aureus* ATCC 25923. The antimicrobial effect of silver nanoparticles obtained with green tea was demonstrated for these two bacteria up to certain concentrations.

Keywords: silver nanoparticles, green tea, green synthesis, *Escherichia coli*, *Staphylococcus aureus*



SYNTHESIS AND CHARACTERIZATION OF NEW DISPERSED HETEROCYCLIC AZO DYES AND THEIR DYEING PROPERTIES ON POLYAMIDE TEXTILE MATERIAL

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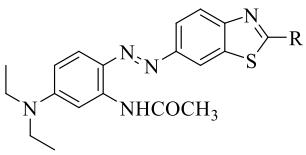
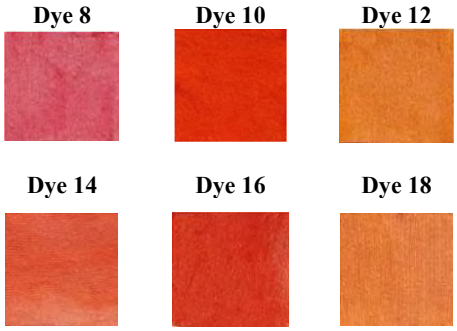
Aromatic diazo components, in the synthesis of azo dyes, are being replaced by heteroaromatic diazo components because the prepared heterocyclic azo dyes show better dyeing properties such as color tone and brightness, and better light fastness compared to the corresponding carbocyclic azo dyes. In this work 6-aminobenzothiazole was prepared by a multi-step synthesis starting from benzothiazole, which served as a diazotizing component for copulation reactions on commercially available 3-(*N*,*N*-diethylamino)acetanilide. The described methods effectively prepared bis-disulfide derivative, which served as a reagent for condensation reactions in DMSO with variously substituted aromatic aldehydes. In this way, six previously undescribed 6-azo-2-phenyl-disubstituted benzothiazole derivatives were prepared in high yields. The structure of all prepared compounds was confirmed using ^{1}H and ^{13}C NMR spectroscopy and mass spectrometry, and the molar absorption coefficient was determined by recording quantitative UV-Vis spectra. The obtained dyes have been tested as disperse dyes for polyamide (PA) textile material. All six tested dyes have good application properties for dyeing polyamide textile material and excellent fastness to washing.

Keywords: multi-step synthesis, heterocyclic azo dyes, disperse dyes, dyeing, color fastness



5 R = H
8 R = 4-NO_2Ph
10 R = 4-*N*,*N*-diEtPh
12 R = 4-ClPh
14 R = 4-CNPh
16 R = 3-NO_2Ph
18 R = 2-OHPh



Polyamide (**PA**) fabrics coloured with azo dyes **8**–**18** at a dye concentration of 0.5%

IZRADA SUNČANIH ĆELIJA NA OSNOVI NANOKRISTALIČNOG TiO_2 I FOTOAKTIVNIH BOJILA

PREPARATION OF SOLAR CELLS BASED ON NANOCRYSTALLINE TiO_2 AND PHOTOACTIVE DYES

Pero Dabić, Damir Barbir, Karmen Kunčić

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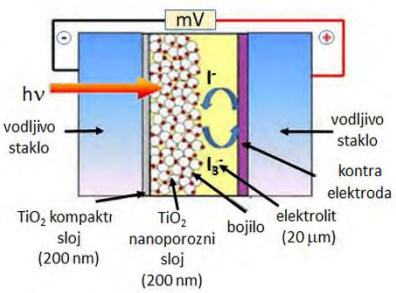
Suvremeni način života suočava se sa dva oprečna izazova: povećanom potrebom za električnom energijom te imperativ smanjenja utjecaja na životnu sredinu konvencionalnih načina proizvodnje električne energije, koja se u velikoj mjeri dobiva spaljivanjem fosilnih goriva. Radi ovih razloga istražuju se alternativni načini dobivanja električne energije iz obnovljivih izvora, koji su ekološki prihvatljiviji. Danas je već uobičajeno korištenje sunčanih ćelija u svrhu dobivanja električne energije od malih solarnih panela pa do velikih sunčanih elektrana značajnih kapaciteta. Većina komercijalnih sunčanih panela je na bazi polikristalnog silicija sa učinkovitošću pretvorbe od 15-20 %. Intenzivnim istraživanjem razvijene su različite vrste tankoslojnih sunčanih ćelija druge i treće generacije, a naročito su ekološki zanimljive one sa nanokristaličnim filmom TiO_2 i ZnO te fotoaktivnim bojilima (eng. *dye-sensitized* solar cell, DSSC) [1]. Razvijena su komercijalna fotoaktivna bojila sa organometalnim kompleksima na bazi rutenija, a intenzivno se istražuje primijena fotoaktivnih bojila ekstrahiranih iz prirodnih izvora [2]. U ovome radu uspoređena je fotoaktivnost sunčanih ćelija uz primijenu gel elektrolita te komercijalnog bojila, N3 i antocijanina ekstrahiranog iz hibiskusa (lat. *Hibiscus sabdariffa*).

Ključne riječi: DSSC, nanokristalični TiO_2, fotoaktivno bojilo, N3, antocijanin

[1] M. Grätzel, *J. of Photochem. and Photobiol. C: Photochem. Rev.* 4 (2003) 145-153.
[2] K. Sharma et al., *Nanoscale Research Letters* 3 (2018) 1-46.



FOTOLITIČKA RAZGRADNJA *N*-NITROZAMINA
PHOTOLYTIC DEGRADATION OF N-NITROSAMINES

Katarina Marija Drmić, Karla Krešić, Sandra Babić,
Silvia Morović, Krešimir Košutić

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Reakcijom dezinficijensa s prirodnom organskom tvari i anorganskim tvarima prisutnim u vodi nastaju dezinfekcijski nusprodukti (DNP) koji štetno djeluju na zdravlje ljudi. Iako je identificirano više od 700 DNP-a, zakonom su regulirani samo trihalometani (THM) i haloocetene kiseline (HAA). DNP-i koji sadrže dušik, poput nitrozamina, značajno doprinose toksičnosti vode za piće. Stoga je nužan razvoj učinkovitih metoda uklanjanja DNP-a iz vode, kao što su napredni oksidacijski i membranski procesi. U ovom radu istražena je fotolitička razgradnja *N*-nitrozamina u ultračistoj, bazenskoj i bočatoj vodi te u retentatu nakon RO/NF postupka korištenjem UV-LED fotoreaktora. Proučavani *N*-nitrozamini su: *N*-nitrozodimetilamin (NDMA), *N*-nitrozopirolidin (NPYR), *N*-nitrozodietilamin (NDEA), *N*-nitrozomorfolin (NMOR) i *N*-nitrozopiperidin (NPIP) . Kao izvor zračenja, korištene su UV-A (λ = 365 nm) i UV-C (λ = 272 nm) svjetleće diode. Istražen je utjecaj valne duljine zračenja, udaljenosti između LED dioda i reaktora te broja LED dioda na kinetiku razgradnje *N*-nitrozamina. Fotoreaktor s UV-A LED diodama i s njihovim najvećim brojem, te najmanjom udaljenosti od reaktora bio je najučinkovitiji u razgradnji *N*-nirozamina u svim ispitanim matriksima tijekom vremenskog perioda od 60 min. *N*-nitrozamini zaostali u retentatu nakon membranske obrade s reverzno osmotskim membranama uspješno su uklonjeni fotolitičkom razgradnjom.

Ključne riječi: *N*-nitrozamini, fotoreaktor, fotolitička razgradnja, UV-LED diode

SYNTHESIS OF A MOLECULARLY IMPRINTED CORE-SHELL PHOTOCATALYST

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Gordana Matijašić[2], Lidija Ćurković[1]

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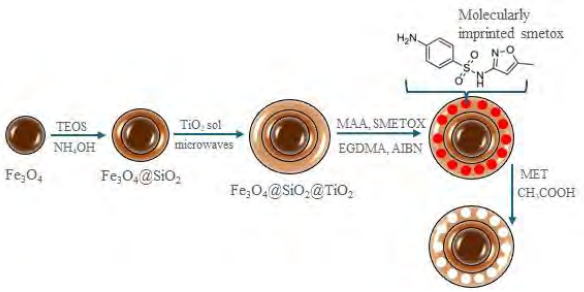
Extensive research has been done into developing effective strategies for the removal of pharmaceutically active compounds. The main drawback of commercial processes such as photocatalysis is the separation of photocatalysts from the solution. For this purpose, a magnetic nanostructured core-shell photocatalyst with a molecular imprint of sulfamethoxazole was prepared via microwave-assisted synthesis. The magnetite core was coated with a protective layer of SiO_2 and a photocatalytic layer of molecularly imprinted TiO_2. Microwave radiation enables fast and uniform heating rate, rapid nucleation and growth of particles, shortens reaction time and enables energy savings, while the magnetite core enables easy separation by an external magnet as well as the possibility for reuse. The molecularly imprinted TiO_2 layer possess specific cavities designed for the target molecule (imprint) that will improve the efficiency of the extraction process, thus creating a synergistic effect of photocatalysis and extraction. The obtained photocatalyst was examined by means of XRD, FTIR, BET, DRS and SEM.

Keywords: nanocomposite, photocatalyst, microwave-assisted synthesis

This work was funded by the Croatian Science Foundation under the project [HRZZ-IP-2022-10-4400]: Development of molecularly imprinted polymers for use in analysis of pharmaceuticals and during advanced water treatment processes (MIPdePharma).



MEHANOKEMIJSKA SINTEZA KVATERNIH SOLI *N*-ACILHIDRAZONSKIH DERIVATA PIRIDOKSAL HIDROKLORIDA

MECHANOCHEMICAL SYNTHESIS OF QUATERNARY SALTS N-ACYLHYDRAZONE DERIVATIVES OF PYRIDOXAL HYDROCHLORIDE

Dajana Gašo-Sokač[1], Valentina Bušić[1], Dora Zobundžija[1], Aleksandra Čavlek[1], Sunčica Roca[2]

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Zbog važnog biološkog djelovanja, vitamin B6 se već dugi niz godina intenzivno istražuje. Osim što je jedan od vitamina iz skupine vitamina B-kompleksa, koji su nužni za normalno funkcioniranje živčanog sustava, vitamin B6 potreban je za normalno funkcioniranje metabolizma lipida, glukoze te aminokiselina, a bitan je i u brojnim enzimskim aktivnostima. U kontekstu važnosti vitamina B6, kemičari su usmjerili napore u sintezu različitih strukturno modificiranih derivata vitamina B6 i ispitivanje njihove biološke aktivnosti. Posebna pažnja je usmjerena na sintezu novih hidrazonskih i *N*-acilhidrazonskih derivata piridoksal hidroklorida koji pokazuju antituberkuloznu aktivnost kao i sposobnost keliranja željeza. U radu su uspješno pripravljene kvaterne soli *N*-acilhidrazoniskih derivata piridoksal hidroklorida (1-16). Konvencionalna sinteza nije dala ciljane soli, dok se mehanokemijska sinteza pokazala izvrsnom i dušik pridinskog prstena uspješno je kvaterniziran reakcijom sa supstituiranim fenacil-bromidima (-H, -F, -Cl, -Br, -NO_2, -CH_3, -OCH_3, -Ph). Reakcije su se odvijale u vibracijskom mlinu pri frekvenciji 30 Hz uz dodatak male količine otapala (aceton).

Ključne riječi: mehanokemijska sinteza, piridoksal, kvaterne soli, *N*-acilhidrazoni

SYNTHESIS OF FATTY ACID 2-PROPYL AND 2-OCTYL ESTERS FROM RAPESEED OR PALM OIL

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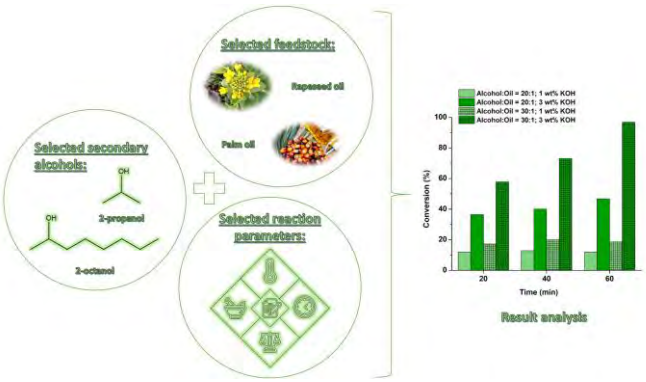
Environmental pollution and climate change caused by the combustion of fossil fuels have led researchers to turn to alternative, renewable sources of energy, such as biofuels. Biodiesel, *i.e.* fatty acid alkyl esters, is a biofuel that is most often synthesized by a transesterification reaction from vegetable oils or animal fats, and an alcohol (most commonly methanol or ethanol), in the presence of a catalyst, usually a homogeneous alkaline catalyst (potassium or sodium hydroxide) [1]. In this research, the selected feedstock, rapeseed or palm oil, was transesterified with a selected secondary alcohol (2-propanol or 2-octanol) in the presence of different catalysts (potassium hydroxide or sulfuric acid) into fatty acid alkyl esters. The reaction temperature was kept constant (60 °C), as well as the mixing speed (150 rpm), while the mass fraction of the catalyst (1 or 3 %), the molar ratio of the reactants (20:1 or 30:1) and the reaction time (20, 40, 60 min, 8 h, 1 or 7 days) varied during the experiments. The initial results showed that the molar ratio of the reactants and the mass fraction of the catalyst had the greatest influence on the increase in the reaction conversion.

Keywords: biodiesel, transesterification, secondary alcohol, rapeseed oil, palm oil

[1] S. M. Y. Kosuru, Y. Delhiwala, P. B. Koorla, M. Mekala, *GRETS* 2 (2024) 100061.



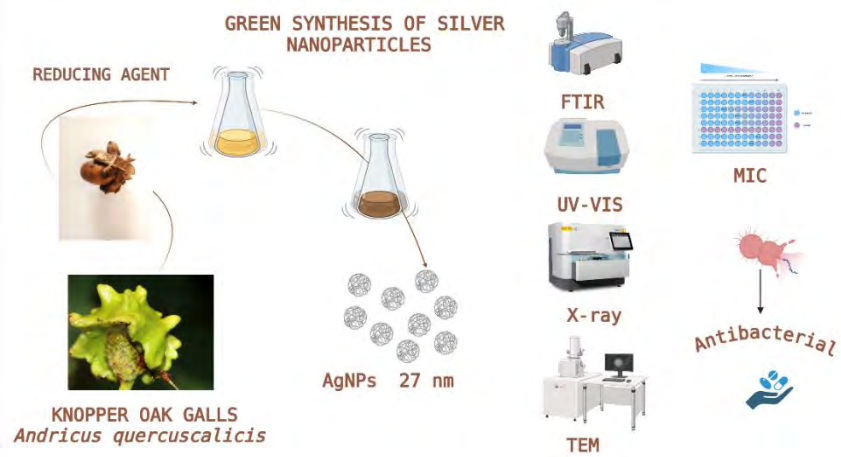
GREEN SYNTHESIS OF SILVER NANOPARTICLES BY USING KNOPPER GALL EXTRACTS

Vlatka Gvozdić[1], Elvira Kovač-Andrić[1], Valentina Pavić[2], Ivan Ćorić[3], Klara Kirchbauer[1]

[1]*Josip Juraj Strossmayer University of Osijek, Department of Chemistry, Ulica cara Hadrijana 8/A, 31000 Osijek*
[2]*Josip Juraj Strossmayer University of Osijek, Department of Biology, Ulica cara Hadrijana 8/A, 31000 Osijek*
[3]*Josip Juraj Strossmayer University of Osijek, Faculty of Medicine, Josipa Huttlera 4, 31000 Osijek*

Knopper galls are chemically induced distortions of acorns on pedunculate oak (*Quercus robur* L.) trees caused by gall wasps of the genus *Andricus quercuscalicis*. Galls develop on various plant parts during feeding or after egg-laying, influenced by plant hormones like auxin and cytokinin, which also increase tannin production. Tannins, with strong reducing properties, are suitable for green synthesis of silver nanoparticles. This study synthesized silver nanoparticles using tannin-rich extracts of Knopper galls and $AgNO_3$ solution. Characterization through FT-IR, UV-visible spectrophotometry, PXRD, and TEM confirmed successful synthesis, showing a UV-Vis absorption peak at 413 nm and a nanoparticle size of 27 nm. FT-IR identified biomolecules responsible for synthesis, and PXRD confirmed the crystalline nature of the nanoparticles. The synthesized nanoparticles exhibited strong antibacterial properties against *E. coli*, *P. aeruginosa*, *B. subtilis* and *S. aureus*.

Keywords: oak gall wasps, *Quercus robur* L, tannins, FT-IR, PXRD, TEM, antibacterial



TALOŽENJE NESTABILNE HIDRATNE FORME KALCIJEVA OKSALATA
PRECIPITATION OF THE UNSTABLE HYDRATED FORM OF CALCIUM OXALATE

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Biomineralizaciju gledamo kao proces stvaranja biominerala u živim organizmima. Kada dođe do neželjenog stvaranja biominerala govorimo o patološkoj biomineralizaciji. Tada dolazi do stvaranja patološki mineraliziranih tvorbi, npr. bubrežnih kamenaca. Stvaranje bubrežnih kamenaca uzrokuje kroničnu bolest urinarnog trakta – urolitijazu. Bubrežni kamenci su sve češća pojava u današnjem svijetu, a njihovom stvaranju pridonose prehrana i ubrzan način života. U više od 80% slučajeva prevlada kalcij oksalatni sastav. Kalcijev oksalat može se pojaviti u tri hidratne forme, stabilan kalcijev oksalat monohidrat (COM), nestabilan kalcijev oksalat dihidrat (COD) i nestabilan kalcijev oksalat trihidrat (COT). U bubrežnim kamencima COM i COD se češće pojavljuju dok je COT rijetko prisutan, ali se pretpostavlja da upravo taj hidratni oblik prvi nastane te transformira u COM. U ovom radu provedena je sinteza nestabilne faze kalcijeva oksalata, te je proučena morfologija dobivenih kristala. Sinteze su provedene pri tri različite temperature (25, 36,5 i 48 °C) i tri ionske jakosti (0,01, 0,05 i 0,1 mol dm^{-3}). Analiza dobivenih kristala provedena je pomoću optičke mikroskopije, infracrvene spektroskopije s Fourierovom transformacijom (FTIR), rendgenske difrakcije na prahu (XRD) i termogravimetrijske analize s pretražnom kalorimetrijom (TGA-DSC). Rezultati pokazuju da pri 25 i 36,5 °C nastaje COT dok povišenjem temperature na 48 °C nastaje COM neovisno o ionskoj jakosti. Zaključno s time temperatura u ovom slučaju ima veći utjecaj na nastajanje nestabilne faze, obzirom da pri nižim temperaturama (25 i 36,5 °C) i svim ionskim jakostima uvijek nastaje COT, dok pri višoj temperaturi (48 °C) neovisno o ionskim jakostima nastaje COM.

Ključne riječi: urolitijaza, bubrežni kamenci, kalcijev oksalat, kalcijev oksalat trihidrat

ISKORIŠTAVANJE GORKE MORSKE VODE ZA DOBIVANJE VATROSTALNOG MgO

UTILIZATION OF SEAWATER BITTERN FOR OBTAINING REFRACTORY MAGNESIUM OXIDE

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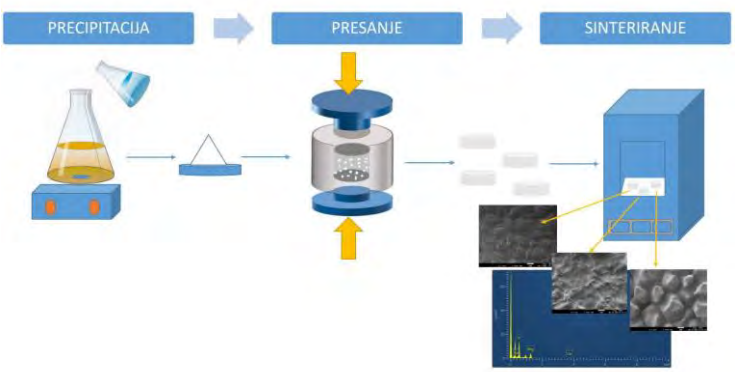
Gorka morska voda (*engl. Seawater bittern)* visokog saliniteta (299,8-310,4 g L^{-1}) sadrži koncentraciju magnezijevih iona od 30 do 40 kg m^{-3} te predstavlja perspektivan izvor magnezijevih soli. Izdvajanje magnezijevih soli u obliku magnezijeva oksida moguće je primjenom procesa precipitacije uz zasićenu vodu vapnenicu, tj. taložnog reagensa u stehiometrijskom odnosu. Dobiveni prah predstavlja aglomerirane čestice magnezijeva oksida (veličine nm) koji se presanjem oblikuju u ispreske u cilju dobivanja vatrostalnog magnezijeva oksida sinteriranjem pri temperaturama 1400 °C, 1500 °C i 1600 °C. Istraživala se morfologija, sastav, gustoća i poroznost dobivenog vatrostalnog magnezijeva oksida. Rezultati su pokazali da postoji eksponencijalna ovisnost gustoće i poroznosti ovisno o temperaturi sinteriranja. Povećanjem temperature veličina zrna i gustoća rastu dok se poroznost smanjuje. Iz SEM/EDS analize uzoraka vidljive su granice zrna periklasa uz prisustvo pora. Nadalje, kemijskim sastavom potvrđena je prisutnost visoke koncentracije bora koja se smanjuje povećanjem temperature, ali još uvijek u višim koncentracijama od dozvoljenih za vatrostalni materijal (manje od 0,05 mas.%).

Ključne riječi: gorka morska voda, sinteriranje, gustoća, poroznost, vatrostalni MgO



VOLATILE ORGANIC COMPOUNDS AND FATTY ACID CONTENT OF GREEN MACROALGAE *Ulva lactuca*

Stela Jokić[1], Igor Jerković[2], Ivana Flanjak[1], Krunoslav Aladić[1], Drago Šubarić[1], Zorana Mutavski[3], Rozelindra Čoz-Rakovac[4]

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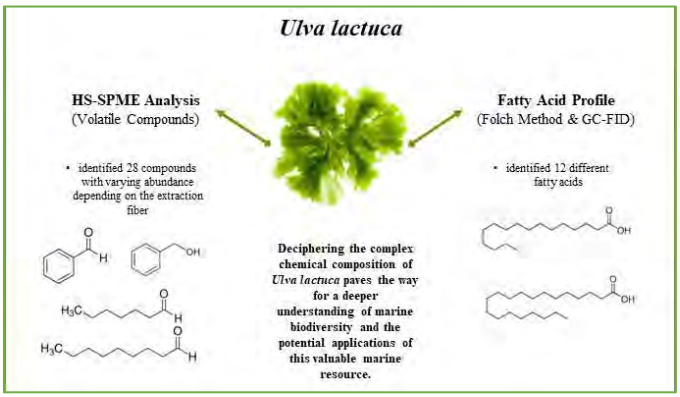
Since macroalgae represent a valuable source of various bioactive compounds it is important to investigate their chemical profiles that will lead to the better understanding of marine algal biodiversity in the Adriatic Sea, in this case *Ulva lactuca*.

Total of 28 compounds were extracted by HS-SPME and identified by GC-MS with relatively different compounds abundance among the fibers. Unsaturated alkane heptadec-8-ene ranged in the headspace from 21.80% to 12.46%. Other abundant compounds were lower aldehydes heptanal and nonanal, followed by minor percentages of pentanal, hexanal, octanal and decanal. Benzyl alcohol and benzaldehyde were the main benzene derivatives in the headspace. Total lipids were extracted using the Folch method and analysed using GC-FID. Twelve (12) fatty acids were identified. The content of palmitic, oleic acid isomers and arachidic acid consist more than 70% of total identified fatty acids (45.16%, 13.59% and 14.57%, respectively).

Keywords: Ulva lactuca, bioprospecting, fatty acids, volatiles, extraction

We would like to thank Croatian Government and the European Union through the European Regional Development Fund - the Competitiveness and Cohesion Operational Programme (KK.01.1.1.01) for funding The Scientific Centre of Excellence for Marine Bioprospecting - BioProCro.



FERROCENE-CONTAINING PYRIMIDINE DERIVATIVES OF CURCUMIN: SYNTHESIS, ANTIOXIDANT AND ANTIMICROBIAL ACTIVITY

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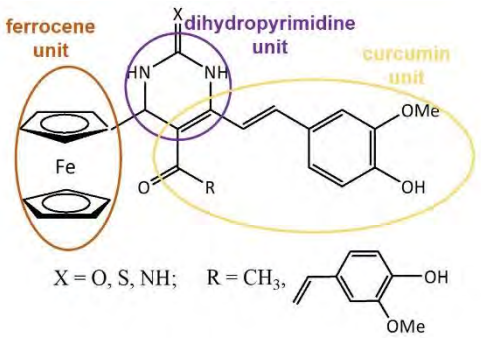
Despite the numerous pharmacological properties of curcumin, its clinical use is limited due to its poor bioavailability and solubility. One of the strategies to overcome these disadvantages and increase its biological activity is structural modification [1]. Considering that ferrocene is a very good candidate for organometallic derivatization of natural products, we have synthesized new ferrocenyl-pyrimidine derivatives of curcumin using a Biginelli-like multicomponent reaction and investigated their antioxidant and antimicrobial properties. The tested derivatives (1 mM) showed antioxidant activity against both DPPH and ABTS radicals in the range of 0.11-0.27 and 0.53-1.59 mM Trolox, respectively. Of the five derivatives synthesized, two derivatives at a concentration of 164.89 mmol and 160.64 mmol inhibited the growth of Gram-positive bacteria: *S. aureus*, *B. subtilis*, *E. faecium* and *L. monocytogenes*, as well as the Gram-negative bacteria *E. coli* and *S. enterica* s. Typhimurium. The 3,4-dihydropyrimidine-2-thione derivative of curcumin had the highest antimicrobial activity.

Keywords: ferrocene, pyrimidine, curcumin derivatives, antioxidant and antimicrobial activity

This work has been fully supported by Croatian Science Foundation under the project IP-2020-02-9162.

[1] S. A. Noureddin et al., *Eur. J. Med. Chem.* 182 (2019) 111631.



SYNTHESIS AND STRUCTURAL CHARACTERIZATION OF NOVEL 2-BENZOXAZOLONE−1,2,3-TRIAZOLE HYBRIDS

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Heterocyclic biologically active compounds often incorporate heteroatoms, such as nitrogen, oxygen and sulfur, which significantly impact the reactivity of the core, drug-target interactions in living organisms, and pharmacokinetics [1]. 2-Benzoxazolone is a natural cyclic carbamate obtained from plants. By varying substitution at different positions, the 2-benzoxazolone nucleus exhibits diverse biological properties and therefore is considered as a privileged structure in medicinal chemistry [2]. Furthermore, the 1,2,3-triazole ring is not found in nature, but its stability in acidic and basic conditions, as well as its resistance to metabolic degradation, make it an excellent candidate for the synthesis of hybrids [1].

To create variously substituted hybrids of 2-benzoxazolone and 1,2,3-triazole linked by a methyl linker, we employed a multi-step synthesis approach. Initially, 2-benzoxazolones with different substituents at the C-5 position were propargylated at the N-3 position with propargyl bromide in the presence of a base. Furthermore, various phenyl azides were synthesized through $HCl/NaNO_2$-mediated diazotization reaction of substituted anilines using sodium azide. Finally, the new 2-benzoxazolone−1,2,3-triazole hybrids were synthesized by Cu(I) catalayzed 1,3-dipolar cycloaddition reaction of the obtained alkynes and azides.

Keywords: 2-benzoxazolone, 1,2,3-triazole, hybrids

[1] K. Bozorov, J. Zhao, H. A. Aisa, *Bioorg. Med. Chem.* 27 (2019) 3511.
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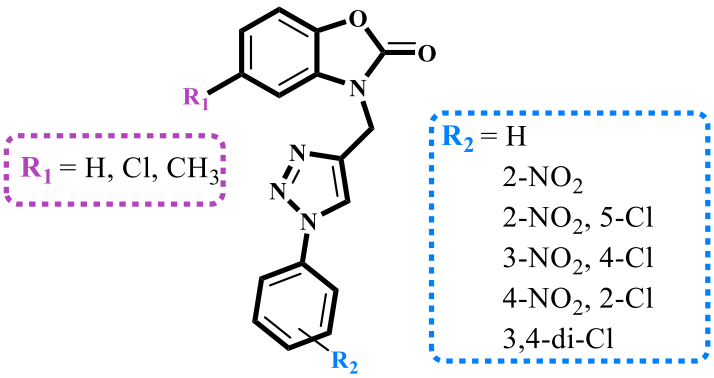

SINTEZA I KARAKTERIZACIJA *N*1- I *N*1/*N*3-URACILNIH DERIVATA FEROCENA

SYNTHESIS AND CHARACTERIZATION OF N1- AND N1/N3-URACYL DERIVATIVES OF FERROCE

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Vezivanje organometalnih fragmenata na nukleobaze pokazalo se kao zanimljiva strategija za poboljšanje učinkovitosti lijekova i smanjenje njihove toksičnosti. U tom smislu, ferocen je dobar izbor kao bioizosterična skupina zbog svoje stabilnosti i dobro poznate reaktivnosti i elektrokemije [1]. U potrazi za bioorganometalnim sustavima s proširenom konjugacijom u prethodnim istraživanjima naše skupine sintetizirani su novi hibridi s karbonilnom poveznicom između heterocikličkog i organometalnog dijela koji su uključivali homoanularno supstituirani ferocenski supstrat. Karbonilna skupina definira prostornu relaciju, omogućuje i elektronsku komunikaciju dvaju fragmenata ovih biokonjugata [2]. U nastavku istraživanja ispitati će se utjecaj metoksikarbonilne skupine u acilirajućem supstratu na međusobni odnos *N*1- i *N*1/*N*3-sintetiziranih hetreroanularno supstituiranih derivata ferocena. Struktura novih spojeva biti će potvrđena FTIR i NMR spektroskopijom.

Ključne riječi: organometalni nukleozidi, uracil, ferocen

[1] P. Chellan, PJ. Sadler, *Chem. Eur. J.* 26 (2020) 8676.
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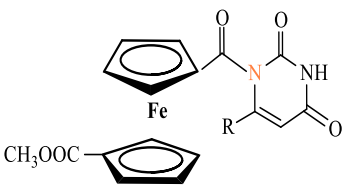
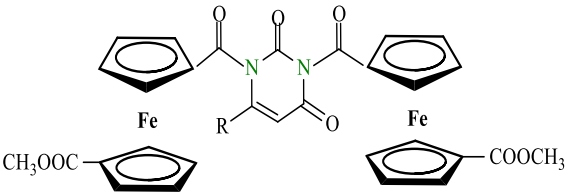


N1-



N1/N3-

R = H, CH_3, F, Cl, Br, I

PRIPRAVA I KARAKTERIZACIJA HIDRAZIDNIH MAKROCIKLIČKIH I ACIKLIČKIH SPOJEVA IZVEDENIH IZ DIPIKOLINSKE KISELINE

SYNTHESIS AND CHARACTERIZATION OF HYDRAZIDE MACROCYCLIC AND ACYCLIC COMPOUNDS DERIVED FROM DIPICOLINIC ACID

Silvia Midenjak[1], Tatjana Gajić[1], Žana Dupljak[1], Dominik Goman[1], Maja Molnar[2], Ivana Balić[1], Tomislav Balić[1], Martina Medvidović-Kosanović[1]

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Piridin-2,6-dikarboksilna kiselina (*pdc*) i derivati se mogu koristiti kao polidentatni ligandi za pripravu koordinacijskih spojeva ili pak detekciju štetnih kemijskih vrsta. Hidrazidni derivati *pdc*-a su posebna skupina koja posjeduje specifično *N*,*N*,*N*-donorsko mjesto koje služi za vezanje specifičnih otapala, plinova ili metalnih kationa [1]. Hidrazidni derivati *pdc*-a također se mogu iskoristiti za sintezu makrocikličkih Schiffovih baza. Ovisno o dizajnu makrocikličkog liganda, pripravljeni spojevi mogu selektivno vezati određene kemijske vrste, poglavito metalne katione [2]. Cilj ovog istraživanja je priprava te strukturna i elektrokemijska karakterizacija dva hidrazidna spoja (1 (aciklički spoj) i 2 (makrociklički spoj)) uporabom cikličke voltametrije, IR i NMR spektroskopije te rentgenske strukturne analize. Rezultati karakterizacija spojeva navedenim metodama u skladu s pretpostavljenim molekulskim formulama (1 i 2). Ciklička voltametrija je pokazala da spoj 1 nije elektrokemijski aktivan, dok spoj 2 pokazuje jedan ireverzibilni oksidacijski strujni vrh pri potencijalu, $E_{p,a}$ = 0,86 V.

Ključne riječi: makrociklički spojevi, sinteza, voltametrija, strukturna karakterizacija

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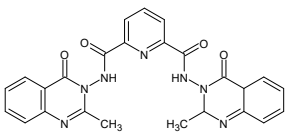

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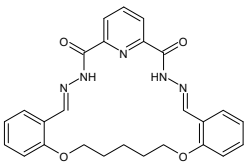

2

PRIMJENA INFRACRVENE SPEKTROSKOPIJE U ANALIZI ORGANOSILANA

APPLICATION OF INFRARED SPECTROSCOPY IN THE ANALYSIS OF ORGANOSILANES

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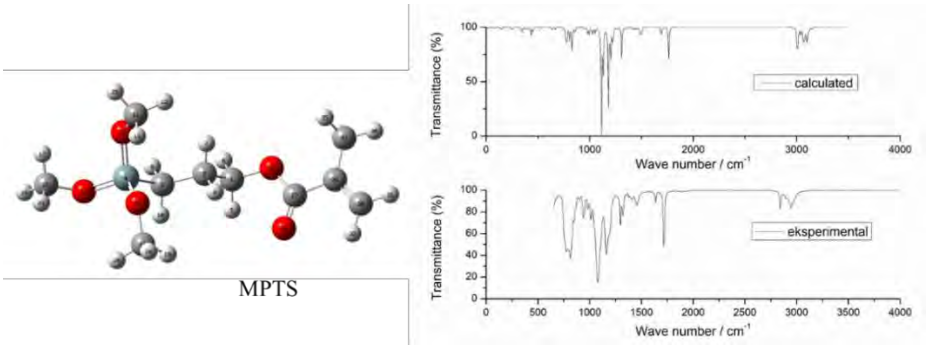
U radu su uspoređeni eksperimentalno dobiveni infracrveni spektri sa spektrima izračunatim kvantnokemijskim proračunima pomoću programskog paketa Gaussian 09, koji primjenjuje teoriju funkcionala gustoće (DFT) za četiri organosilana: 3-aminopropilsilantriol (APST), 3-aminopropiltrietoksisilan(APTS), 3-glicidoksipropiltrimetoksisilan (GPTS) i 3-metakriloksipropiltrimetoksisilan (MPTS). U eksperimentalnim spektrima jasno su prepoznatljive vrpce funkcionalnih skupina za APTS, GPTS i MPTS. U spektru APTS vidljive su vrpce amino skupine, istezanja veze ugljik-vodik u propilnom lancu te etoksi skupine. Spektar GPTS-a pokazuje karakteristične vrpce epoksi prstena, istezanja veza ugljik-vodik i metoksi skupine, dok MPTS spektar jasno prikazuje dvostruku ugljikovu vezu, estersku funkcionalnu skupinu te istezanja veza ugljik-vodik u propilnom lancu i metoksi skupini. U spektru APST-a, molekula vode prekriva vrpce amino skupina i istezanja veza ugljik-vodik.
Usporedbom opaženih frekvencija iz navedenih spektara s teorijskim izračunima, kao i s podacima iz literature uočava se dobro podudaranje. Na temelju uspoređenih podataka, može se zaključiti da kvantnokemijski izračuni dobro predviđaju vibracijske spektre odabranih molekula, što je značajno jer omogućava dodatni pristup u istraživanju materijala s ciljem unaprjeđenja njihovih svojstava.

Ključne riječi: organosilani, infracrvena spektroskopija, DFT



FERROCENE ESTER AND AMIDE DERIVATIVES OF DESMURAMYL PEPTIDES: SYNTHESIS AND ANALYSIS OF INTRAMOLECULAR INTERCATIONS AND INTERACTIONS WITH NOD2 RECEPTOR

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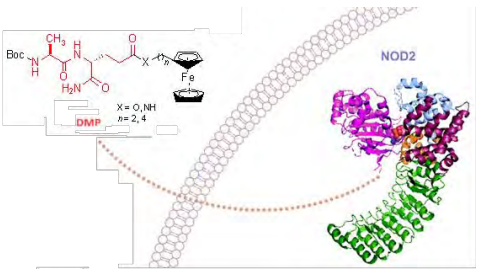
Desmuramyl peptide (L-Ala-D-*iso*Gln, DMP) is a pharmacophore of muramyl dipeptide (Mur*N*Ac-L-Ala-D-*iso*Gln, MDP), a peptidoglycan fragment which stimulates immune response. MDP activates NOD2 and through cascade events stimulates the production of cytokines. [1] In this work we described synthesis and structural characterization of ferrocene ester and amide derivatives of DMP with ferrocene subunit connected via linkers of different lenghts (ethyl or butyl) on the side chain of D-*iso*Gln. The conformational properties of the prepared conjugates were examined using IR and NMR spectroscopies, while the potential of the compounds for NOD2 receptor activation was explored computationally.

Keywords: conformational analysis, computational investigation, desmuramil peptide, ferrocene esters and amides

[1] A. Kamboj, M. T. Patil, N. Petrovsky, D. B. Salunke, *Eur. J. Med. Chem.* 271 (2024) 116439.

This work has been fully supported by Croatian Science Foundation under the project IP-2020-02-9162.



SINTEZA METAKRILATNIH POLIMERNIH ADITIVA S MONOMERIMA NA OSNOVI LAURINSKE I STEARINSKE KISELINE ZA DIZELSKO GORIVO

SYNTHESIS OF METHACRYLATE POLYMER ADDITIVES WITH MONOMERS BASED ON LAURIC AND STEARIC FOR DIESEL FUEL

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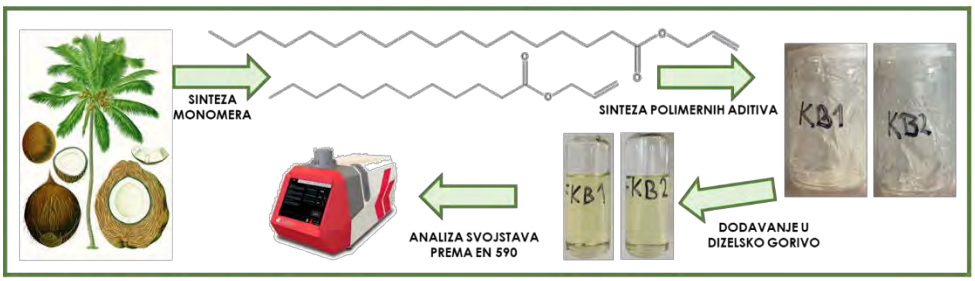
Moderna goriva bi teško mogla zadovoljiti današnje standarde korištenja s obzirom na očuvanje okoliša bez dodatka aditiva. Aditivi se dodaju u goriva najčešće kako bi ih se jednostavnije skladištilo, smanjile emisije štetnih plinova prilikom korištenja i poboljšala neka svojstva vezana uz klimatske karakteristike poput sprječavanja smrzavanja pri niskim temperaturama. Oni su najčešće po sastavu polimerni materijali, a kako bi se zadovoljili ciljevi Europske komisije za kružnom ekonomijom, prikladno bi bilo sastav izmijeniti biokomponentama. U prijašnjim istraživanjima razvili smo polimerne aditive na osnovi metakrilatnih monomera koji su uspješno poboljšali neka od svojstava dizelskoga goriva, te su u ovome istraživanju neki od tih monomera zamijenjeni monomerima na osnovi prirodno dostupnih masnih kiselina iz palminog i kokosovog ulja, laurinskom i stearinskom kiselinom. Novosintetizirani aditivi dodani su u prethodno neaditvirano dizelsko gorivo te su pokazali da poboljšavaju tecište dizelskoga goriva za 12 °C, a pritom negativno nisu utjecali na ostala primjenska svojstva poput gustoće i viskoznosti.

Ključne riječi: aditivi, masne kiseline, niskotemperaturna svojstva, dizelsko gorivo



STUDY OF THE CHANGE IN THE CONCENTRATION OF FLUORIDE IONS IN SOLUTIONS STORED IN GLASS PACKAGING

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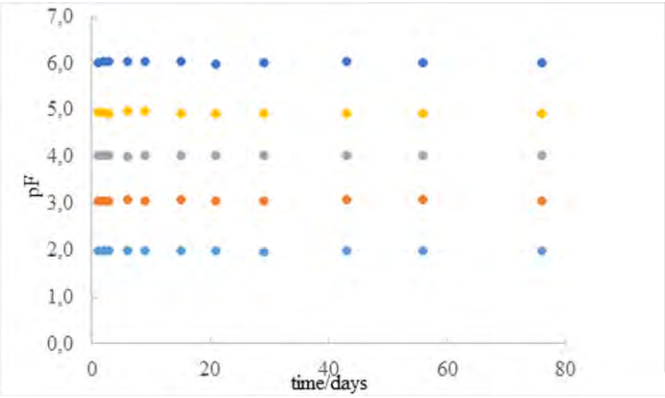
Glass, one of the most important materials in everyday life, is resistant to many chemicals. However, it is not completely inert. In this study, the change in the concentration of fluoride ions in standard solutions of different concentrations of sodium fluoride (from 1.0×10^{-6} to 1.0×10^{-2} mol L^{-1}) stored in glass packaging was investigated. The concentrations were determined using a new mathematical model of the standard addition method [1, 2].
It was found that the originally prepared concentrations of the standard solutions stored in glass containers do not change significantly, i.e. they fluctuate slightly over time around the originally prepared concentrations. Since no significant changes in the concentration values were observed for any of the solutions tested during the entire measurement period, it can be concluded that the storage of solutions with a pH value of 5.3 in glass containers has no influence on the fluoride concentration in this solution.

Keywords: fluoride, glass, potenciometric, standard addition method

[1] J. Radić, Doctoral thesis, University of Split, Faculty of Chemistry and Technology, 2022, str. 72-75.
[2] M. Buljac, M. Bralić, N. Vladislavić, J. Dugeč, J. Radić, *Chemistry* 5 (2023) 2588-2597.



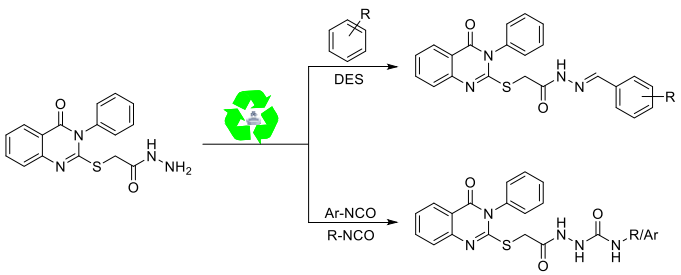
AN ECO-SAFE APPROACH: MECHANOCHEMICAL SYNTHESIS OF HETEROCYCLES BASED ON QUINAZOLINONE CORE

Hana Rašek, Mario Komar, Martina Jakovljević Kovač, Maja Molnar
Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek

Mechanochemical synthesis represents an eco-safe method for preparing heterocycles through the reactions facilitated by mechanochemical force. It presents a green alternative to traditional organic synthesis by reducing solvent consumption [1]. The quinazolinone core, recognized for its broad spectrum of biological activities, plays an important role in medicinal chemistry [2]. This study focuses on optimizing the reaction conditions for mechanochemical synthesis, such as milling time and the volume of the deep eutectic solvent (DES). A series of Schiff bases was prepared by the condensation between quinazolinone hydrazide and aromatic aldehydes with the addition of choline chloride/malonic acid (1: 1) as a solvent. Semicarbazides were prepared solvent-free using quinazolinone hydrazide with aliphatic and aromatic isocyanates. The synthesized compounds were characterized using mass spectrometry and NMR spectroscopy confirming their structures. This approach not only aligns with the principles of green chemistry but also improves the feasibility of heterocycles in an eco-safe manner.

Keywords: mechanochemistry, quinazolinone, Schiff base, semicarbazide

[1] T. Friščić, C. Mottillo, H. M. Titi, *Angew. Chem.* 59 (2020) 1018.
[2] S. N. Murthy Boddapati et al., *Arab. J. Chem.* 16 (2023) 105190.



ANTIMICROBIAL COATINGS FOR MEDICAL DEVICES, SURGICAL THREADS AND ELECTROSPUN YARNS

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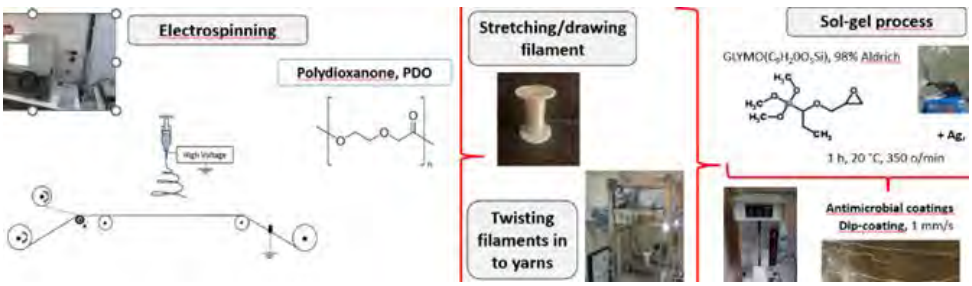
The rise of antibiotic-resistant bacteria and the high incidence of hospital-acquired infections necessitate the development of advanced antimicrobial coatings for medical applications [1]. This research focuses on the creation and optimization of antimicrobial coatings for medical devices, biocompatible surgical threads, and electrospun yarns. By employing various techniques such as sol-gel processes and dip-coating methodologies, we have successfully integrated antimicrobial agents, including metal nanoparticles (Ag, Pt, Au, TiO_2, ZnO), into these materials without compromising their mechanical properties. The tensile tests indicate that the mechanical properties of the coated electrospun filament yarns remain unaffected, while preliminary antimicrobial tests demonstrate significant efficacy against Methicillin-resistant Staphylococcus aureus (MRSA) and Methicillin-sensitive Staphylococcus aureus (MSSA) when applying optimized formulated mixture of antimicrobial nanoparticles. Scanning Electron Microscopy (SEM) reveals the need for ultrasonic homogenization steps to ensure uniform distribution of nanoparticles. This study highlights the potential of these coated materials in reducing infection rates and enhancing the performance of medical devices and surgical implements. Future work will focus on optimizing the homogenization process and expanding the range of antimicrobial agents to further improve the effectiveness and biocompatibility of these innovative materials.

Keywords: antimicrobial nanoparticles, medical devices, electrospun, surgical threads, yarn

[1] I. Rezić, Antimicrobial Coatings for Biodegradable Polymers: The Medical Nanorevolution, Cambridge Scolar Publishing, 2023, ISBN: 9781527536487.



MAKRO I MIKRO ELEKTROKEMIJSKO ISPITIVANJE EPOKSIDNE PREVLAKE

MACRO AND MICRO ELECTROCHEMICAL MEASUREMENT OF EPOXY COTING

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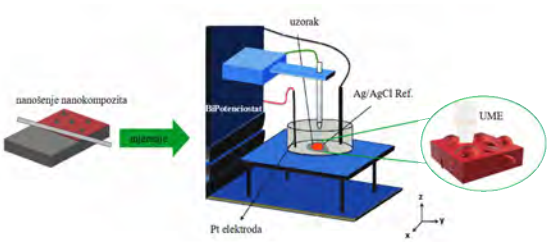
Klasične elektrokemijske metode, poput elektrokemijske impedancijske spektroskopije (EIS), pružaju uvid u prosječno ponašanje cijele ispitivane površine. Međutim, rezultati ovih metoda ponekad su teški za tumačenje zbog lokalne pojave degradacije prevlake, poput mjehurenja. Osim toga, EIS ne pruža informacije o mjestu nastanka mikropore ili mikropukotine te stoga nije pogodna metoda za proučavanje mehanizama degradacije prevlake [1]. Kako bi se prevladale ove prepreke, razvijena je Pretražna elektrokemijska mikroskopija (SECM) koja otvara mogućnost istraživanja početnih faza elektrokemijske korozije. Primarni cilj ovog istraživanja je nadopuniti EIS mjerenja sa SECM rezultatima na različitim uzorcima epoksidne prevlake obogaćene s 1 % nanočestica aluminija i grafenovim oksidom. U radu su provedena makro i mikro elektrokemijska mjerenja, uključujući cikličku voltametriju i EIS, u 3,5 %-tnoj otopini NaCl-a. Rezultati ispitivanja pokazali su da SECM mjerenja identificiraju aktivna i pasivna područja za proučavanje lokalne degradacije nanočestica unutar epokisne prevlake. Također, dodatak nanočestica pruža veći otpor čime se poboljšava antikorozivna zaštita.

Ključne riječi: elektrokemijska impedancijska spektroskopija, pretražna elektrokemijska mikrosopija, aluminijeve nanočestice, grafenov oksid

[1] S. Farrokhpay, *Appl. Spectrosc. Rev*. 47 (2012) 3.



VOLATILE COMPOUNDS OF FLAVOURED CHEESES

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The composition and content of volatile compounds of full-fat hard cheese and the same cheese to which aromatic herbs were added in different proportions were analysed. The cheeses were produced in Puđa d.o.o., Trilj. Livanjski sir, a full-fat hard cheese made from a mixture of cow's and sheep's milk, served as the base. Three herb species were prepared for the cheese production: lavender (*Lavandula officinalis* L.), basil (*Ocimum basilicum* L.) and sage (*Salvia officinalis* L.). Each herb species was prepared in two concentrations: 0.05% and 0.25%. Isolation of volatile compounds was performed by solid phase microextraction (HS-SPME) using divinylbenzene/carboxen/polydimethylsiloxane fiber (DVB/CAR/PDMS) at a temperature of 60 °C. All samples were analysed by gas chromatography-mass spectrometry (GC-MS) using a non-polar column and the results were compared.

In all samples, the most abundant compounds were carboxylic acids, especially the fatty acids butanoic, hexanoic and octanoic acid as well as propanoic and acetic acid. Terpenes were also identified in all the cheeses analysed. A higher number of terpenes was identified in the flavoured cheeses than in the cheese without aromatic herbs, with the exception of the lavander-flavoured cheese (0.05%). Monoterpene compounds, the hydrocarbon limonene and the alcohols linalool and terpinen-4-ol predominated in the headspace of the lavander-flavoured cheese. The main constituents of the basil-flavoured cheese were the monoterpenes limonene and linalool. Sage flavoured cheeses had a significant amount of α-thujone, which is specific to Dalmatian sage, but other monoterpenes such as limonene, linalool and camphor were also present in significant amounts. The following applies to all flavoured cheeses: the higher the proportion of a particular aromatic plant in the cheese, the higher the number and proportion of terpenes, with the terpenes specific to a particular plant standing out.

Keywords: volatile compounds, flavoured cheese, HS-SPME, GC-MS

HLAPLJIVI SPOJEVI LIKERA PELINKOVCA
VOLATILE COMPOUNDS OF PELINKOVAC LIQUEUR

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Pelinkovac je jako alkoholno piće koje ima dugu tradiciju proizvodnje na području Republike Hrvatske. Pripada kategoriji biljnih likera, a dobiva se aromatiziranjem etilnog alkohola poljoprivrednog podrijetla maceratima aromatičnog bilja u kojima po sastavu i količini dominira biljka pelin (*Artemisia absinthium* L.), uz komorač (*Foeniculum vulgare* L.), kadulju (*Salvia officinalis* L.) i mentu (*Mentha piperita* L.), koji proizvodu daju prepoznatljiva i karakteristična organoleptička svojstva. Cilj ovog rada bio je usporediti aromatični profil pet likera Pelinkovca prisutnih na tržištu Republike Hrvatske. Hlapljivi spojevi izolirani su mikroekstrakcijom vršnih para na krutoj fazi (HS-SPME) i analizirani vezanim sustavom plinska kromatografija-masena spektrometrija (GC-MS). Glavni spojevi u ispitanim uzorcima bili su terpeni. U uzorcima A, B i E dominirao je *trans*-anetol (36,10 %, 43,21 % i 39,20 %), u uzorku C limonen (52,82 %) te u uzorku D *p*-menton (25,76 %). Utvrđene razlike u aromatičnom profilu uzoraka Pelinkovca upućuju na specifičnosti pojedinog proizvođača u odabiru aromatičnog bilja i tehnološkom procesu proizvodnje.

Ključne riječi: biljni liker, pelinkovac, hlapljivi spojevi, HS-SPME, GC-MS

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KEMIJSKO I BIOKEMIJSKO INŽENJERSTVO

CHEMICAL AND BIOCHEMICAL ENGINEERING

SINTEZA I KARAKTERIZACIJA NOVOG CIJEPLJENOG KOPOLIMERA KSANTAN GUME S POTENCIJALNOM PRIMJENOM U STABILIZACIJI FARMACEUTIKA

SYNTHESIS AND CHARACTERIZATION OF A NOVEL XANTHAN GUM GRAFT COPOLYMER WITH POTENTIAL USE AS A PHARMACEUTICAL STABILIZER

Rafael Anelić, Fabio Faraguna

Sveučilište u Zagrebu, Fakultet kemijskog inženjerstva i tehnologije,
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Napretkom medicine i farmaceutike svakim danom se otkriva sve veći broj potencijalnih farmaceutika. Međutim, značajan problem novootkrivenih farmaceutika je njihova slaba topljivost u vodi [1]. Mnoge su rute koje se istražuju kako bi se riješio problem dostave lijeka na ciljano mjesto. Jedna od mogućnosti je korištenje amorfnih čvrstih disperzija (*eng.* Amorphous Solid Dispersions - ASD) u kojoj je farmaceutik raspršen unutar nosača koji inhibira njegovu kristalizaciju i time olakšava otapanje u vodi [1,2]. Najčešće korišteni nosači su upravo sintetski i prirodni polimeri. Prirodni polimeri su polisaharidi poput natrijeve soli karboksimetil celuloze, hidroksipropil metilceluloze, ksantan gume, itd. [2,3]. Ovaj rad uključuje modifikaciju ksantan gume cijepljenom kopolimerizacijom te karakterizaciju cijepljenog kopolimera metodama infracrvene spektroskopije s Fourierovom transformacijom (FTIR), termogravimetrijskom analizom te diferencijalnom pretražnom kalorimetrijom. FTIR analizom pokazalo se povećanje transmitancije određenih signala, a termalnim analizama je utvrđeno da je sintetizirani materijal različitih toplinskih svojstava od početnog materijala. Analize su uspješno pokazale da je cijepljena kopolimerizacija provedena jednostavnim reakcijskim postupcima, a kako bi se potvrdila stabilizacija farmaceutika provest će se daljnja istraživanja.

Ključne riječi: amorfne čvrste disperzije, ksantan guma, cijepljena kopolimerizacija, farmaceutici

[1] U. H. Gala, D. A. Miller, R. O. Williams, *Biochimica et Biophysica Acta (BBA) - Reviews on Cancer* (2020).
[2] P. Pandi, R. Bulusu, N. Kommineni, W. Khan, M. Singh, *Int J Pharm.* (2020).
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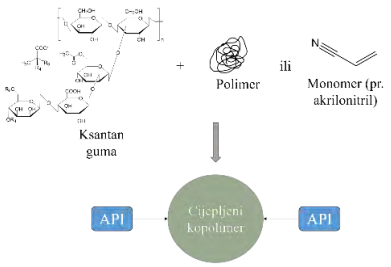

Inhibicija kristalizacije farmaceutika zbog interakcije sa cijepljenim kopolimerom

PROCES GRAFTIRANJA PLA MALEINSKIM ANHIDRIDOM
PLA GRAFTING PROCESS WITH MALEIC ANHYDRIDE

Nikica Baričević, Ena Miletić, Karla Stražičić, Lucija Vlahović, Roko Blažic, Dajana Kučić Grgić, Vesna Ocelić Bulatović

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Potencijalnu alternativu primjeni sintetskih polimera kao ambalažnih materijala predstavljaju prirodni, biorazgradljivi polimeri poput poli(mliječne kiseline) (PLA). Međutim, mehanička svojstva PLA, poput krtosti i nedostatka fleksibilnosti [1], onemogućuju njegovu primjenu u industriji pakiranja. Stoga se razvijaju biorazgradljive mješavine na osnovi PLA čiji je nedostatak loša mješljivost polimera koja se može poboljšati primjenom kompatibilizatora [2]. Mogući kompatibilizator polimernih mješavina na osnovi PLA jesu graft kopolimeri koji kao osnovni lanac sadrže PLA. Primjer takvog kopolimera jest PLA graftiran maleinskim anhidridom (PLA-g-MA) koji osigurava dispergiranost jedne polimerne faze u drugoj te poboljšava međufaznu adheziju polimera u mješavini [3]. Steričke smetnje i moguće neželjene reakcije poput umreživanja PLA ili polimerizacije MA u prisutnosti inicijatora smanjuju učinkovitost procesa graftiranja [3]. Stoga je cilj ovoga rada priprema PLA-g-MA radikalskom polimerizacijom u taljevini, koristeći dibenzoil peroksid (DBP) kao inicijator. Kako bi se postigao što veći stupanj graftiranja, BPO i MA dodavani su u različitim udjelima, u različitim vremenskim intervalima te u različitim slijedovima. Graftiranje MA na PLA istraženo je nuklearnom magnetskom rezonancijom (NMR), kromatografijom u plinskoj fazi (GC), diferencijalnom pretražnom kalorimetrijom (DSC) i termogravimetrijskom analizom (TGA).

Ključne riječi: poli(mliječna kiselina), maleinski anhidrid, graftiranje

[1] S. Farah, D. G. Anderson, R. Langer, *Adv. Drug Deliv. Rev.* 107 (2016) 367-392.
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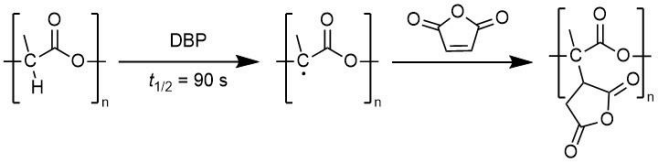
[3] S. W. Hwang et al., *Polym. Test.* 31 (2012) 2.

Ovo istraživanje provedeno je u sklopu projekta „*Proizvodnja i razvoj kompostabilne ambalaže iz otpadne biomase za pakiranje industrijski prerađenih prehrambenih proizvoda*" (NPOO.C3.2.R3-I1 .04.0059) financiranog iz Nacionalnog plana oporavka i otpornosti (financiranog od strane Europske unije, NextGenerationEU).



SORPTION OF COPPER IONS ON IMMOBILISED ZEOLITE AND YEAST

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University of Split, Faculty of Chemistry and Technology, Ruđera Boškovića 35, 21000 Split

Copper is one of the essential metals for many industrial and agricultural processes. However, it is toxic, does not biodegrade, and can accumulate in living organisms. Because of this, wastewater contaminated with copper must be treated before it is released into the environment. This research explored utilising of NaX zeolite particles and *Saccharomyces cerevisiae* yeast immobilised in alginate (A) for copper ions removal from solutions. Zeolites are widely used sorbents for the removal of pollutants [1]. Yeast is commonly used to treat high concentration organic wastewater, wastewater containing heavy metals and household sewage. Immobilization of the yeast boosts its activity and facilitates separation [2].
The immobilised NaX and yeast removal capabilities were examined concerning initial metal ion concentration at 300 K. Immobilised NaX and yeast were prepared with sodium alginate and calcium chloride. The results show that an increase in the initial copper solution concentration from 2.165 to 9.825 mmol L^{-1} resulted in a decrease in the removal percentage from 70.244 to 30.291 % when immobilised zeolite was used. Using immobilised yeast, the removal efficiency first increased from 7.654 to 10.338 % for the initial concentrations of 2.165 to 9.825 mmol L^{-1} and then decreased to 4.51% for the highest concentration used. The copper sorption data on immobilised NaX and yeast was tested with four types of isotherm models with Langmuir's isotherm model being the most appropriate equation to describe the experimental equilibrium data. The FTIR spectra of the sorbents used, recorded prior and after sorption, revealed no changes in the structure of the sorbents.

Keywords: zeolite NaX, yeast *Saccharomyces cerevisiae,* sorption, copper ions

[1] M. S. Hellal, A. M. Rashad, K. K. Kadimpati et al., *Scientific reports* 13 (2023) 19601.
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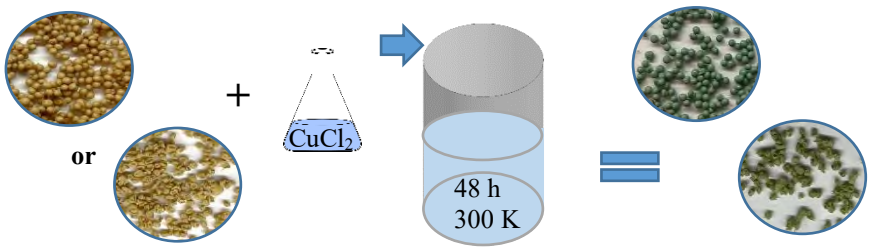

WHEN POSITION MATTERS – DIFFERENT PHOTOPHYSICAL PROPERTIES OF TWO TETRACYCLIC IMIDAZO[4,5-*b*]PYRIDINE REGIOISOMERS

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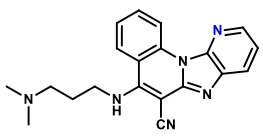
[2]*Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb*

We investigated spectroscopic and acid/base features of two tetracyclic imidazo[4,5-b]pyridine regioisomers A and B in various organic solvents and water, which differ in the position of a single pyridine nitrogen atom. The latter introduced significant changes in their optical properties and a difference of 0.46 units in their pK_a values, which are intriguing and worth rationalizing. Their photophysical features revealed solvatochromism in both absorption and emission spectra. In addition, while one system exhibited hypsochromic shifts, the other displayed bathochromic shifts in UV/Vis absorption maxima. A similar contrasting response was also noted in emission spectra, where regioisomers showed opposite spectral changes in acidic conditions. Computational DFT analysis demonstrated that, under normal conditions, both systems exist as monocations protonated at chain amines. Above pH = 8.7, they convert to unionized neutrals, yet without any notable change in UV/Vis spectra, leaving this process hidden to this technique. In contrast, below pH ≈ 3 both systems exchange to dications, with one most preferably protonated on imidazole, while the other on pyridine. As such, different dications gave dissimilar UV/Vis responses, with computed absorption maxima and shifts induced by this exchange found in excellent quantitative agreement with experiments. These results highlight the profound influence of the pyridine nitrogen position within studied regioisomers, which allows a fine-tuning of their spectral properties in various condensed media and promotes these systems as promising pH-sensing materials [1].

Keywords: imidazo[4,5-*b*]piridin, regioisomers, optical pH sensors, computational DFT analysis

[1] (a) A. Beč, R. Vianello, M. Hranjec, *J. Mol. Liq.* 386 (2023) 122493; (b) I. Boček, M. Hranjec, R. Vianello, *J. Mol. Liq.* 355 (2022) 118982; (c) N. Perin, D. Babić, P. Kassal, A. Čikoš, M. Hranjec, R. Vianello, *Chemosensors* 10 (2022) 21.



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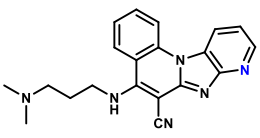

B

SVOJSTVA BIOKOMPOZITA OTPADNE LJUSKE ORAŠASTIH PLODOVA I GEOPOLIMERA
PROPERTIES OF WASTE NUTSHELL AND GEOPOLIMER BIOCOMPOSITES

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Uzimajući u obzir održivost i očuvanje okoliša potreban je razvoj novih i naprednih materijala na ekološki prihvatljivoj bazi upotrebom otpadnih materijala. Ljuske orašastih plodova su biomaterijali koji se kao otpadni nusprodukt najčešće koriste kao gorivo, dok je primjena u biokompozitima posebice s anorganskom matricom većinski neistražena. Jedan od kandidata za anorgansku matricu su geopolimeri, keramički materijali dobiveni aktivacijom alumosilikatnih praškastih prekursora otopinama hidroksida alkalijskih metala, a predstavljaju ekološki prihvatljivu zamjenu za portland cement. U ovome radu ispitana su svojstva biokompozita dobivenih iz otpadne ljuske lješnjaka i badema s geopolimernom matricom. Ljuske su obrađene mercerizacijom s varirajućim koncentracijama i vremenom predobrade kako bi se postigla bolja adhezija te kompatibilnost ljuske i geopolimera. Predobrada se provela s 3, 6 i 9 % otopinom NaOH te s 12,5 % suspenzijom vapna pri 80 °C 1 i 2,5 sata. Mjerene su tlačne i savojne čvrstoće pripremljenih kompozita nakon 1, 7 i 28 dana vezanja pri sobnoj temperaturi i 40 °C s geopolimerima pripremljenih iz kalijevih i natrijevih aktivacijskih otopina zamiješanih s metakaolinom i lebdećim pepelom kao čvrstim prekursorima. Kompoziti dobiveni iz lebdećeg pepela i prije provedenih mjerenja su pokazali izrazito loša svojstva, isto kao i kompoziti vezani pri 40 °C. Kompoziti pripremljeni iz metakaolina i kalijevih aktivacijskih otopina pokazali su superiorna svojstva nad kompozitima pripremljenim s natrijevim aktivacijskim otopinama.

Ključne riječi: geopolimeri, biokompoziti, otpadna ljuska, mercerizacija

ANALIZA ANTIMIKROBNOG UČINKA EKSTRAKATA ČEŠNJAKA (*Allium sativum*) NA PATOGENE MIKROORGANIZME VODA

ANALYSIS OF THE ANTIMICROBIAL EFFECTS OF GARLIC (Allium sativum) EXTRACTS ON WATERBORNE PATHOGENIC MICROORGANISMS

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Istraživanje antimikrobnih svojstava raznih prirodnih spojeva postaje sve značajnije zbog rastuće otpornosti mikroorganizama na dosad široko korištene antibiotike. Češnjak (*Allium sativum*), poznat po svojoj kulinarskoj vrijednosti, od davnina je cijenjen i zbog svojih ljekovitih svojstava. Sadrži niz biološki aktivnih spojeva, uključujući mnoge s antimikrobnim svojstvima. U ovom je radu ispitivan antimikrobni učinak različitih ekstrakata domaćeg i kupovnog češnjaka (porijeklom iz Kine) na patogene mikroorganizme koji su prisutni u prirodnim vodama. Za pripravu ekstrakata korišteni su aceton, etanol, metanol i ultra čista voda. Mikrobiološka ispitivanja provedena su metodom izbušenih rupica u agaru na četiri soja bakterija: *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis* i *Listeria monocytogenes*. Najbolje antimikrobno djelovanje pokazao je ekstrakt domaćeg češnjaka u ultračistoj vodi na bakteriji *Listerii monocytogenes*. Uočeno je izraženije antimikrobno djelovanje većine ekstrakata na Gram (+) bakterije u odnosu na one Gram (-). Najslabije antimikrobno djelovanje ekstrakti su pokazali na bakteriji *Pseudomonas aeruginosa*. Pomoću plinske kromatografije spregnute sa spektrometrijom masa (GC-MS) u svim su ekstraktima detektirani spojevi: dialil-sulfid, dialil-disulfid, metil-disulfid, dimetil-trisulfid, metil-alil-disuflid te sumpor. Dobiveni rezultati pružaju uvid u potencijalnu upotrebu prirodnih spojeva iz češnjaka za suzbijanje patogena koji se prenose vodom, čime se doprinosi rješavanju ključnih izazova u javnom zdravstvu i zaštiti okoliša.

Ključne riječi: češnjak, antimikrobno djelovanje, bakterijska rezistentnost, patogeni voda

EFFECT OF SEED MASS ON SONOCRYSTALLIZATION KINETICS OF POTASSIUM SULFATE

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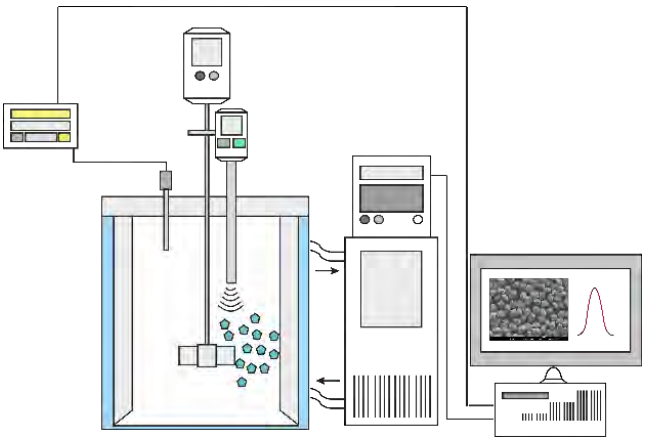
The main focus of this pilot study was to analyze the effect of sonication on the process of seeded batch crystallization of potassium sulfate. Crystallization was conducted in a 2,65 dm^3 vessel in which mechanical mixing and ultrasonic irradiation were applied. A straight blade turbine (SBT) was used for mechanical mixing (D/d_T = 0,53) while sonication was applied by using an ultrasonic homogenizer Hielscher UP400St (400 W, 24 kHz) with a H22L2D sonotrode. Four different seed masses were used and their effect on the crystal growth kinetics and the properties of the end product was investigated as well.
It was found that the crystals were smaller, with significantly narrower crystal size distribution in the sonicated system than in the silent one. The effect of the seed mass shifted the size distribution towards slightly larger crystal sizes. Results also showed that crystal growth is enhanced when the seed mass (load) increases. This was especially pronounced in the sonicated system where crystals achieved their final mean volume diameter early in process time. However, this made them prone to mechanical damage due to mechanical forces caused by the impeller.

Keywords: sonocrystallization, mechanical mixing, seeding, pulsed sonication



BIONANOKOMPOZITI NA BAZI POLIHIDROKSIALKANOATA ZA ODRŽIVO PAKIRANJE HRANE

POLYHYDROXYALKANOATES-BASED BIONANOCOMPOSITES FOR SUSTAINABLE FOOD PACKAGING

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U ovom radu ispitana su svojstva nanokompozita na bazi polihidroksialkanoata, odnosno poli(3-hidroksibutirat-ko-3-hidroksivalerat) s 1, 3, 5, 7 i 10 mas. % titanijeva dioksida (TiO_2), kako bi se ocijenila njihova prikladnost za korištenje u industriji pakiranja hrane. Toplinska svojstva ispitana su diferencijalnom pretražnom kalorimetrijom (DSC) i termogravimetrijskom analizom (TGA). Morfologija prijelomnih površina nanokompozita istražena je pretražnim elektronskim mikroskopom i energodisperzivnim detektorom X-zraka (SEM/EDX). Infracrvena spektrometrija s Fourierovim transformacijama i prigušenom totalnom refleksijom (FTIR-ATR) korištena je za analizu karakterističnih vibracija funkcionalnih skupina. Površinske karakteristike nanokompozita određene su mjerenjem kontaktnog kuta. Uvid u mehanička svojstva materijala, prekidnu čvrstoću, prekidno istezanje, modul elastičnosti i rad loma dobiven je ispitivanjem na mehaničkoj kidalici te analizom krivulja naprezanje/istezanje. Propusnost vodene pare ispitana je Herfeldovom metodom. Rezultati ovih ispitivanja daju uvid u poboljšana svojstva PHBV/TiO_2 nanokompozita te njihovu potencijalnu primjenu u industriji pakiranja hrane kao održiva ambalaža.

Ključne riječi: poli(3-hidroksibutirat-ko-3-hidroksivalerat) (PHBV), titanijev dioksid (TiO_2), nanokompoziti, pakiranje hrane

Ovo istraživanje provedeno je u sklopu projekta „*Proizvodnja i razvoj kompostabilne ambalaže iz otpadne biomase za pakiranje industrijski prerađenih prehrambenih proizvoda*" (NPOO.C3.2.R3-I1 .04.0059) financiranog iz Nacionalnog plana oporavka i otpornosti (financiranog od strane Europske unije, NextGenerationEU).

ANALYSING THE SIZE OF FRAGMENTS RELEASED DURING THE WASHING OF TEXTILES USING THE LASER DIFFRACTION METHOD

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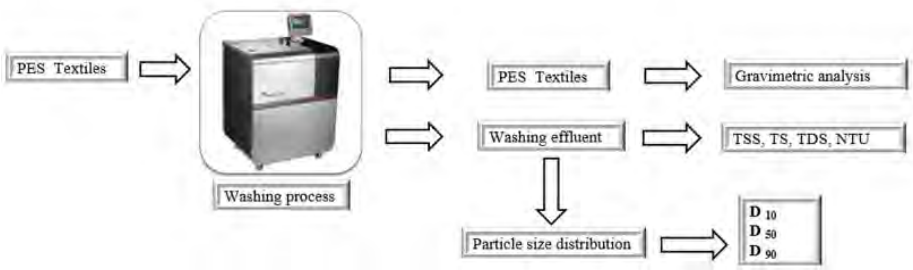
The fragments released during the washing of polyester textiles were analysed after 5 and 10 washing cycles. The washing process was carried out at a temperature of 60 °C with ECE A detergent in a wash bath ratio of 1:7 with 4 rinsing cycles. Effluent analysis was performed using standard methods to determine total solids (TS), total suspended solids (TSS) and total dissolved solids (TDS), turbidity and volume distribution of particle size using the laser diffraction method. Gravimetric analysis was used to monitor the change in mass of the polyester textiles before and after the washing cycles.

The results obtained show the influence of washing cycles on all observed parameters of the solids content as well as on the distribution of particle sizes and their volume fraction in the effluents. Based on the results of the gravimetric analysis, it is clear that the released particles originate from the material. The results originally contributed to the problem of the release of particles in the washing process and the methodology for analysing them.

Keywords: poliester textiles, washing process, particle size distribution



EFFECT OF FORCED AERATION ON IMPROVEMENT OF COMPOSTING PROCESS

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Monika Šabić Runjavec[2], Marija Vuković Domanovac[2]
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Improving the management of solid waste is seen as an environmental challenge. Particular attention is paid to reducing consumption, reducing food waste and converting waste into resources. The management of biodegradable waste has become an increasing challenge in recent decades. Composting is one of the safest and most natural ways to manage biodegradable waste. This process is an efficient and sustainable technology for processing a wide range of organic waste with significant environmental, economic and social benefits.
In this work, the composting process of a real sample of a heterogeneous mixture of biodegradable waste was carried out with a forced aeration of 0.9 m^3/day for 21 days. The initial C/N ratio and volatile matter content were 21 and 55 %, respectively. Based on the parameters estimated by the optimization and using mathematical models to describe the material balance and enthalpy, a process was simulated to compare it with the results of the experiment performed, where the variable aeration affected the temperature control. Aeration is an important factor in regulating composting efficiency. By controlling the aeration regime, the thermophilic phase in the heterogeneous system studied can be kept above 60 °C more than 72 hours.

Keywords: composting process, forced aeration, thermophilic phase, heterogeneous waste

CHARGE DISTRIBUTION AND LITHIUM-OXIDE STABILITY MODELED BY REACTIVE FORCE FIELD

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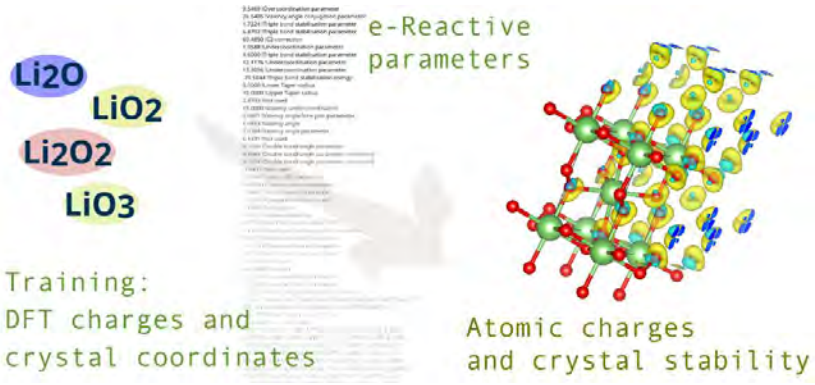
Understanding reactive properties of lithium and its oxides plays important role in modeling and design of lithium-based batteries [1]. For the investigation of reasonably large structures, the use of molecular dynamics is usually the method of choice because of its calculation efficiency [2]. The shortcoming of this approach is that the electron distribution is approximated by parameters obtained semiempirically or from first-principles calculations. A novel method based on Kohn–Sham density functional theory approximated to the second order (ACKS2) modeling the charge distribution based on theoretically sound principles has recently been introduced. Some issues have, however, remained, when this method is applied to lithium-oxides [3]. In this work we first evaluate the effect the charge calculation method has on atomic charges obtained by the model, and then proceed to optimize the chosen force field parameters in an attempt to alleviate the problems perceived previously.

Keywords: reactive force-field, lithium-oxide, ACKS2

[1] C. Prehal et al., *ACS Energy Lett.* 7 (2022) 3112−3119.
[2] A. C. T. van Duin et al., *J. Phys. Chem. A* 105, 41 (2001) 9396–9409.
[3] K. A. O'Hearn et al., *J. Chem. Phys.* 153 (2020) 084107.



UTJECAJ EKSTRAKTA RUŽMARINA NA TOPLINSKU STABILNOST POLIMERNOG KOMPOZITA NA BAZI POLI(ETILEN-OKSIDA)

IMPACT OF THE ROSEMARY EXTRACT ON THE THERMAL STABILITY OF THE POLY(ETHYLENE OXIDE) POLYMER BASED COMPOSITE

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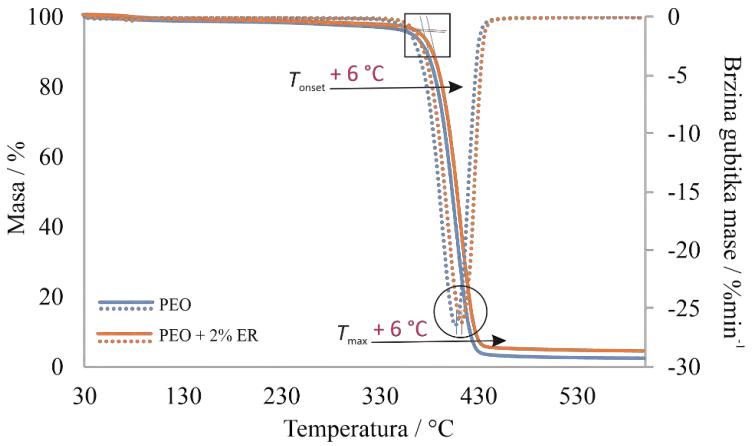
U ovom radu istraživan je utjecaj dodatka ekstrakta ružmarina (ER) na toplinsku stabilnost polimernog kompozita na bazi poli(etilen-oksida (PEO) primjenom neizotermne termogravimetrijske analize (TG). Uzorci kompozita s različitim udjelom ER pripremljeni su u laboratorijskom dvopužnom ekstruderu. Temeljem TG analize određeni su karakteristični parametri toplinske razgradnje (T_{onset} i T_{max}) kompozita u inertnoj atmosferi, te se može zaključiti da dodatak ER poboljšava toplinsku stabilnost polimerne matrice. Također, iz TG krivulja snimljenih pri različitim brzinama zagrijavanja, a primjenom Flynn-Wall-Ozawa i Friedman metode, izračunate su aktivacijske energije toplinske razgradnje. Oblik ovisnosti aktivacijske energije o konverziji daje uvid u složenost procesa razgradnje polimernih kompozita.

Ključne riječi: poli(etilen-oksid, ekstrakt ružmarina, termogravimetrijska analiza, aktivacijska energija



THE THERMAL STABILITY OF POLYLACTIDE/THERMOPLASTIC STARCH BLENDS

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Dajana Kučić Grgić[3], Vesna Ocelić Bulatović[3]

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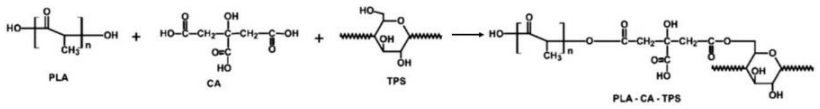
The increase in solid waste from non-biodegradable polymers and the depletion of petroleum resources have heightened environmental awareness and stimulated interest in alternative raw materials, particularly biodegradable plastics from renewable resources. These biodegradable plastics aim to match the properties and cost of conventional polymers. However, they face challenges such as slow degradation rates, higher costs and increased brittleness. Starch is a promising renewable resource as it is available, easy to produce, environmentally friendly, inexpensive and easy to handle. In this study, starch was isolated from two potato varieties (Scala and SL 13–25) grown at the experimental station of the Faculty of Agrobiotechnology in Osijek in 2021. The isolated starches were then processed into thermoplastic starches by extrusion with glycerol as a plasticizer, with and without citric acid (CA) as a compatibilizer/crosslinking agent. The thermal stability and structural properties of blends of thermoplastic starch (TPS) or thermoplastic starch citrate and polylactide (PLA) are investigated. The analysis was performed with a thermogravimetric analyzer. Due to the hydrophilicity of thermoplastic starch (TPS), PLA/TPS blends exhibit significant incompatibility. The addition of CA not only improves the overall thermal stability of TPS/PLA blends but also acts as a crosslinking and plasticizing agent, promoting the formation of the PLA–CA–TPS structure, which results in a new class of biodegradable and environmentally acceptable materials. CA played a key role as an effective compatibilizer, enabling the creation of polymer blends with a uniform microstructure and improved thermal stability.

Keywords: potato starch, thermoplastic starch, polylactide, citric acid, blends

This research was conducted as part of the project „*Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products*" (NPOO.C3.2.R3-I1 .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).



SAFE AND SUSTAINABLE MXENE SYNTHESIS VIA MECHANOCHEMICAL METHOD

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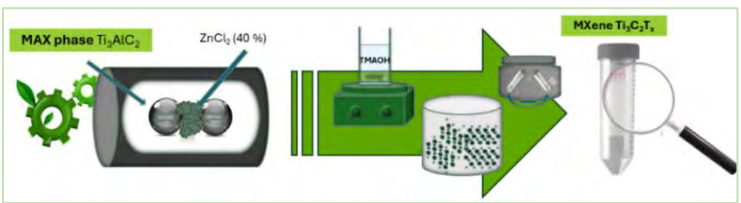
MXenes are transition metal carbides and nitrides that have emerged as one of the fastest-growing groups of 2D materials with great potential for application in supercapacitors, micro-supercapacitors, batteries, fuel and solar cells, composite materials, photocatalysis, biosensors, photodetectors, etc. To date, most MXenes have been prepared through a wet chemical etching method that involves fluoride solutions such as HF or LiF/HCl due to their high efficiency and selectivity. However, fluoride-based solutions are highly hazardous and, their use is associated with considerable safety and handling concerns that are a major barrier to scaling up MXene production. It is therefore desirable to develop simple, safe, reliable as well as sustainable synthetic routes for MXene preparation and practical application.
In this work, we explore mechanochemistry as an alternative route for the MXene preparation. $Ti_3C_2T_x$ was prepared by mechanochemical ball-milling of Ti_3AlC_2 MAX phase with zinc chloride at room temperature. The obtained material was then treated in tetramethylammonium hydroxide to complete the delamination process. The prepared MXene has been studied by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), atomic force microscopy (AFM), Raman spectroscopy and low-energy ion scattering (LEIS) spectrometry.

Keywords: 2D materials, ball-milling, mechanochemistry, solid state



STUDIJA REOLOŠKOG PONAŠANJA TPS/PCL MJEŠAVINA I KOMPOZITA SA TiO_2

STUDY OF RHEOLOGICAL BEHAVIOUR OF TPS/PCL BLENDS AND COMPOSITES WITH TiO_2

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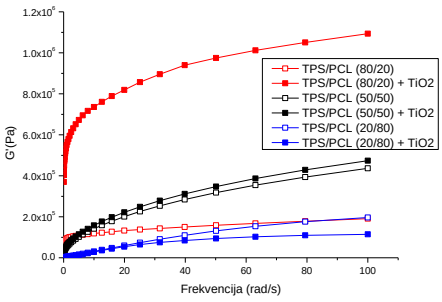
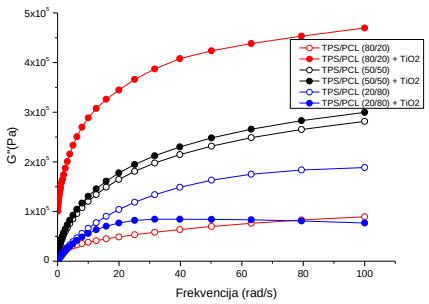
Plastični materijali omogućuju visoku razinu komoditeta i potrošačke navike uobičajene u razvijenim zemljama. Nažalost s njima u vezi prepoznati su brojni okolišni i zdravstveni problemi. Kao moguće rješenje tih izazova istražuje se primjena bioplastike, pri čemu se škrob ističe kao jedan od najzanimljivijih kandidata. Široko dostupni polisaharid u obliku praha, postupkom plastifikacije prevodi se u termoplastični škrob (TPS). U ovom radu priređene su mješavine krumpirovog TPS-a i polikaprolaktona (PCL) sastava 80:20, 50:50 i 20:80 mas.% te njihovi kompoziti s 3 mas.% TiO_2. Uzorci materijala ispitani su na oscilacijskom reometru u frekvencijskom području od 0,1 do 100 rad/s pri amplitudi deformacije 0,5 % i pri stalnoj temperaturi od 120 °C.

U mješavinama najveće vrijednosti modula pohrane *G'* i gubitka *G"* pokazuje mješavina sastava 50:50. Mješavine TPS/PCL 80:20 i 20:80 pri maksimalnoj frekvenciji mjerenja pokazuju slične *G'* vrijednosti, dok se njihovi *G"* značajno razlikuju. Izravna usporedba modula u mješavinama i kompozitima pokazuje tri različita ponašanja: u sustavu TPS/PCL 80:20 kompozit pokazuje cca. tri puta veće vrijednosti od mješavine, kod TPS/PCL 50:50 vrijednosti su vrlo slične, dok kod TPS/PCL 20:80 pokazuju slično ponašanje pri nižim frekvencijama, a pri višim frekvencijama kompozit pokazuje niže vrijednosti obaju modula.

Ključne riječi: termoplastični škrob, polikaprolakton, mješavine, kompoziti, reologija





USE OF PEPPER SEED CAKE TO OBTAIN BIODEGRADABLE PACKAGING MATERIAL

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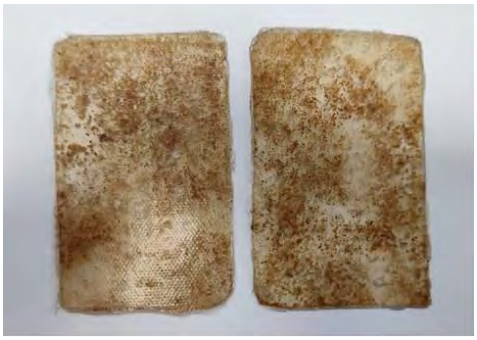
By-products during the processing of fruits and vegetables (seeds, peels, and pulp) are mostly discarded as waste. Research has shown that seeds (2-3% of the fruit) from red sweet peppers (*Capsicum annuum* L.) varieties Podravka and Slavonka are nutritionally valuable organic material to obtain oil rich in bioactive components that makes it suitable for food, cosmetic and the pharmaceutical purposes. Pepper seed cake (by-product after cold pressing of pepper seed) is high in fiber (54%), proteins, carbohydrates, and residual oil (9%). However, due to its emphasized bitterness, incorporating pepper seed cake as ingredient into food products even at very low concentrations, is not organoleptically acceptable. Preliminary results regarding the use of pepper seed cake for producing biodegradable packaging materials indicate its potential as a filler in polymer packaging production. This finding is encouraging because it opens additional opportunities for cascading valorization of by-products from fruit and vegetable processing in a completely new application area: biodegradable packaging materials.

Keywords: by-products fruits & vegetables, pepper seed cake, biodegradable packaging



PLA composite with 5 wt. % cake prepared from a solution

ARTIFICIAL NEURAL NETWORK MODELLING FOR PREDICTION OF MICROORGANISMS NUMBER IN COMPOST SAMPLES BASED ON NIR SPECTRA

Tea Sokač Cvetnić[1], Korina Krog[2], Davor Valinger[2], Jasenka Gajdoš Kljusurić[2], Tamara Jurina[2], Maja Benković[2], Ivana Radojčić Redovniković[2], Ana Jurinjak Tušek[2]

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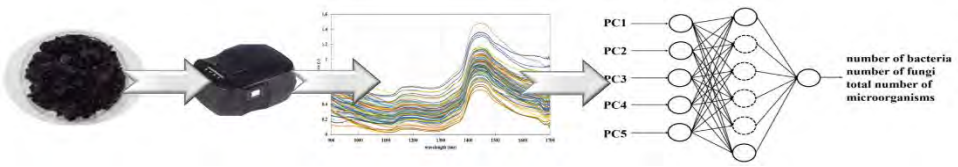
In this work, we coupled near-infrared (NIR) spectra with artificial neural network modeling to predict the number of microorganisms in grape skin compost during 30 days of composting in nine independent composting experiments. NIR spectra were gathered in the wavelength range of λ = 900–1700 nm using a portable NIR instrument. ANNs were developed using first five factors obtained from PCA analysis of NIR spectra after different processing methods as model inputs, and, the number of bacteria, fungi, and the total number of microorganisms as model outputs. Considering the prediction of the number of bacteria, the acceptable pre-processing method for NIR spectra was RER smoothing (RER=10.083). For the number of fungi and the total number of microorganisms, the pre-processing method SG2D+MSC (second-order Savitzky-Golay derivative followed by multiplicative scatter corrections) was the most acceptable and the developed ANN model resulted in the highest RER values of 15.075 and 12.040, respectively.

Keywords: NIR spectra, grape pomace compost, ANN modelling



CHEMICAL PERMEABILIZATION OF *Ralstonia eutropha* H16 CELLS

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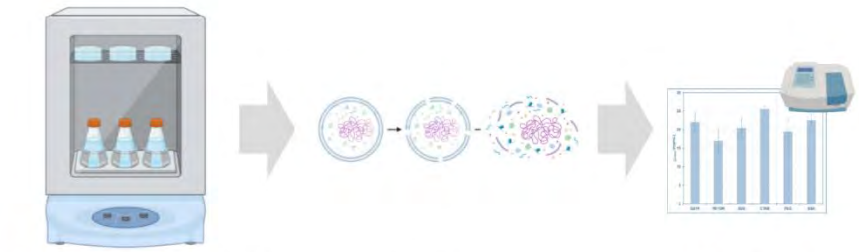
The bacterium *Ralstonia eutropha* H16 has proven to be a versatile microbial platform for the production of various bioproducts, in particular the enzyme hydrogenase, which is crucial for biohydrogen production. Conventional methods for obtaining intracellular products often rely on cell disruption processes (mechanical and non-mechanical), which can compromise cell integrity and viability. As an alternative, cell permeabilization methods offer a promising approach as they facilitate the selective release of intracellular products while preserving cellular integrity to a greater extent. In this study, various permeabilizing agents were used to enhance the extraction of the enzymes from *Ralstonia eutropha* H16 cells. Agents such as EDTA, Triton X-100, SDS, CTAB, PEG, BSA and lysozyme were evaluated for their effectiveness in increasing the permeability of the cell membrane, thereby improving the efficiency of enzyme extraction.

Keywords: Ralstonia eutropha H16, hydrogenase, chemical permeabilization, extraction of intracellular enzymes



OPTIMIZING *Ralstonia eutropha* H16 GROWTH AND ULTRASONIC CELL DISRUPTION

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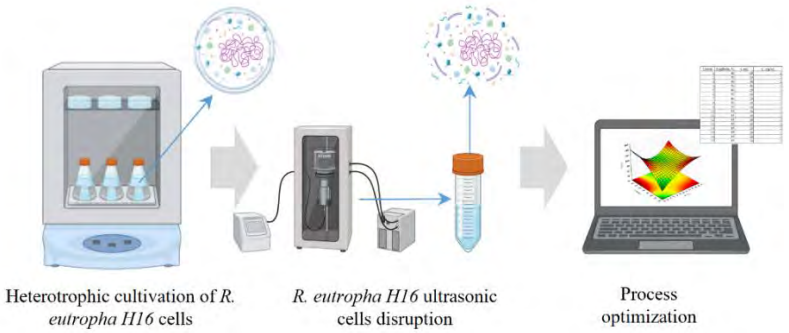
Ralstonia eutropha H16 is a crucial microorganism for biohydrogen production as it can produce the enzyme hydrogenase, which plays an important role in hydrogen metabolism. The aim of this study was the heterotrophic cultivation of *R. eutropha* H16 cells on different synthetic media. During cultivation, the concentrations of biomass and substrate were monitored. The parameters of the mathematical model of the process were estimated from the experimental results by non-linear regression, i.e. using the simplex method and the least squares method integrated in the SCIENTIST software package. The parameters obtained were used to optimize the process. Once the optimal growth conditions were determined, the cells were cultured accordingly. Subsequently, optimization of ultrasonic cell disruption was performed using the Box-Behnken experimental design at three levels (-1, 0, 1) to enhance the release of intracellular bioproducts while minimizing disruption of cell integrity. The results obtained were analyzed using the Statistica 14.0 software package.

Keywords: Ralstonia eutropha H16, hydrogenase, cultivation, ultrasonic cell disruption, process optimization



UTJECAJ KOMERCIJALNIH ŽELJEZOVIH PUNILA NA TOPLINSKA SVOJSTVA POLI(MLIJEČNE KISELINE)

IMPACT OF IRON-BASED FILLERS ON THERMAL PROPERTIES OF POLYLACTIC ACID COMPOSITES

Andrea Špoljarić, Ante Jukić, Elvira Vidović

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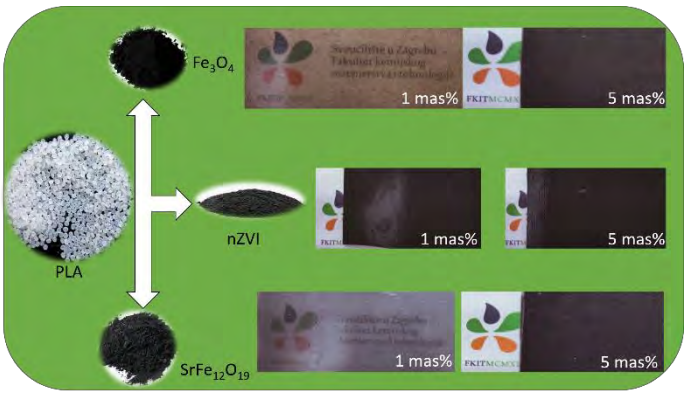
Poli(mliječna kiselina) (PLA) je održiva alternativa konvencionalnim plastikama zbog svoje biorazgradivosti i izrade od obnovljivih izvora poput kukuruznog škroba. PLA smanjuje ugljični otisak jer se razgrađuje u prirodnom okruženju, za razliku od tradicionalnih plastika. Nedavna istraživanja proučavaju kompozite PLA s punilima na bazi željeza za primjenu u tkivnom inženjerstvu. Željezova punila poboljšavaju mehanička svojstva materijala i dodaju funkcionalnosti poput magnetičnosti i katalitičkog djelovanja. Međutim, interakcije punila i polimerne matrice mogu utjecati na toplinska svojstva materijala, što zahtijeva pažljivu optimizaciju. Cilj ovoga rada bio je odrediti utjecaj vrste i količine komercijalnih punila na osnovi željeza na toplinska svojstva PLA kompozita. Za izradu kompozita uzeta je PLA matrica s punilima: magnetit (Fe_3O_4, <50 nm), stroncijev ferit ($SrFe_{12}O_{19}$, 640 nm) te neutralne nanočestice željeza (*engl. nano zerovalent iron particles*, nZVI, 60 nm). Kompoziti su pripremljeni zamiješavanjem u talini pomoću Brabender gnjetilice i prešani u pločice 10 x 10 cm^2. Toplinska svojstva kompozita ispitana su diferencijalnom pretražnom kalorimetrijom, termogravimetrijskom analizom, a njihova toplinska vodljivost mjerena je metodom „vrućeg mosta“. Dodatak 1 mas. % $SrFe_{12}O_{19}$ četverostruko je povećao kristaliničnost kompozita, dok dodatak 1 mas. % nZVI čestica poboljšava toplinsku vodljivost za 20 %.

Ključne riječi: kompoziti, poli(mliječna kiselina), magnetit, stroncijev ferit, neutralne nanočestice željeza



DEVELOPMENT OF A SOFT SENSOR FOR SOLUTE MONITORING AND SUPERSATURATION FEEDBACK CONTROL OF BATCH COOLING CRYSTALLIZATION

Ivan Vrban, Lana Topalović
Teva Pharmaceutical Industries Ltd.,
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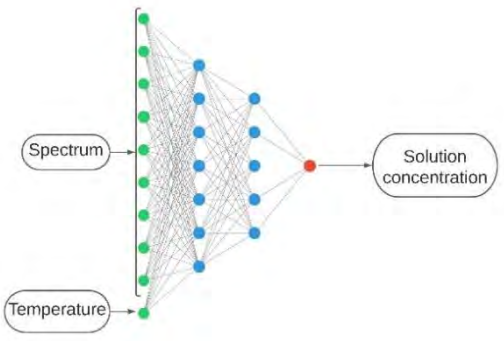
Technological advancements in the past decade have significantly enhanced process analytical technology (PAT), which is now crucial for real-time monitoring and control of critical process parameters, highlighting one of the main aspects of Quality by Design (QbD) and Quality by Control (QbC) principals. This research aims to develop a methodology for continuous solute monitoring and control of the supersaturation level during cooling crystallization, a critical step in production of active pharmaceutical ingredients (APIs).
This research further describes the development of a soft sensor for monitoring solute concentration and supersaturation control during the crystallization of the ceritinib. Soft sensor for solute concentration monitoring is based on in-line UV spectroscopy and data driven models developed with partial least squares regression (PLSR) and artificial neural networks (ANNs). A seeded cooling crystallization of ceritinib from tetrahydrofuran was studied as a model system. The developed soft sensor played a key role in the successful execution of a supersaturation control strategy during crystallization, complemented by in-situ microscopy, turbidimetry and chord length distribution measurement. Implementing this methodology during the development of the cooling crystallization process results in a deeper understanding and development of the more robust process.

Keywords: concentration real-time measurement; crystallization; supersaturation control



RAVNOTEŽA KAPLJEVINA-KAPLJEVINA U SUSTAVU S BUTILNIM ESTEROM MASNIH KISELINA SINTETIZIRANIM IZ KOKOSOVOG ULJA

LIQUID-LIQUID EQUILIBRIUM IN THE SYSTEMS BASED ON FATTY ACID BUTYL ESTER SYNTHESIZED FROM COCONUT OIL

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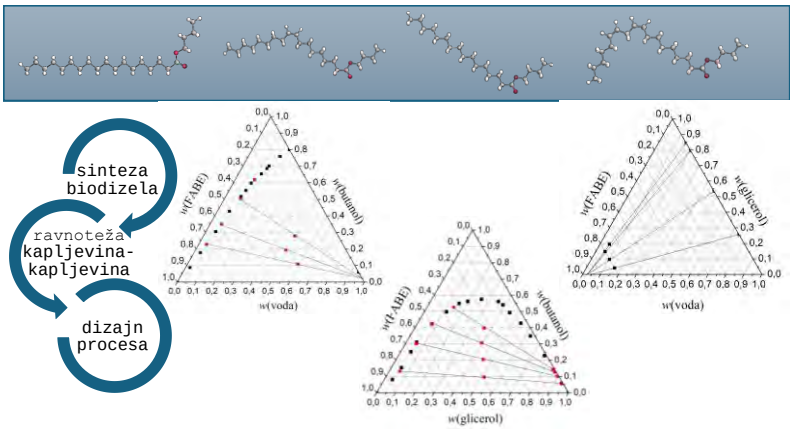
Suvremeni način života zahtijeva intenzivnu upotrebu motornih vozila, što rezultira velikom potrošnjom naftnih prerađevina. S ekološkog i ekonomskog aspekta teži se razvoju i primjeni lako dostupnog i jeftinog goriva. Kao potencijalna zamjena za fosilna goriva proučava se biodizel sintetiziran iz biljnih ulja (butilni ester masnih kiselina, FABE), a za njegovu komercijalnu proizvodnju potrebno je dobro projektirati, dimenzionirati i optimirati procesnu opremu za proces sinteze i pročišćavanja. Za tu svrhu potrebno je poznavanje ravnoteže između reaktanata i produkata reakcije sinteze biodizela. Ona se temelji na zakonitostima ravnoteže kapljevina-kapljevina, a u ovom radu eksperimentalno je određeno i u trokutnom dijagramu prikazano fazno ponašanje u sustavima voda – butanol – FABE, glicerol – butanol – FABE te voda – glicerol – FABE.

Ključne riječi: biodizel, butilni ester masnih kiselina, ravnoteža kapljevina-kapljevina, kokosovo ulje



PREHRAMBENA TEHNOLOGIJA I BIOTEHNOLOGIJA

FOOD TECHNOLOGY AND BIOTECHNOLOGY

HRANA I EMOCIJE
FOOD AND EMOTIONS

Marijana Blažić[1], Karmen Matković Melki[2], Michael Mutshaus[2], Elizabeta Zandona[1], Ines Cindrić[1], Damir Županić[1], Edita Juraga[3], Martina Stvorić[2]

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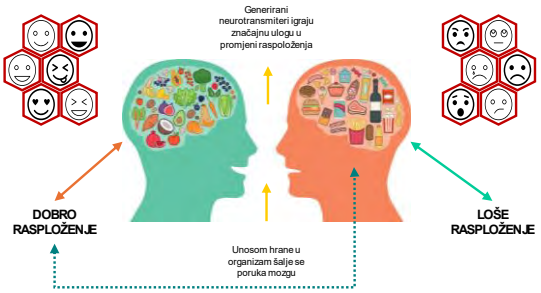
Dosadašnja znanstvena istraživanja dokazuju da hranjive tvari koje unosimo prehranom utječu na kemijski sastav mozga, funkciju živčanog sustava i raspoloženje. Raspoloženje čine brojne emocije koje su sastavni dio ljudske prirode kroz povijest od nastanka ljudske vrste sve do danas. Hrana sadrži važne nutrijente potrebne za sintezu kemijskih spojeva koji sudjeluju u procesu nastanka emocija. Neurotransmiteri su ključna tema ovog rada kao jedni od najvažnijih kemijskih spojeva u tijelu jer prenose živčane impulse između neurona čime sudjeluju u stvaranju emocija. Zbog međuodnosa hrane i živčanog sustava pojavljuje se nova disciplina u gastronomiji; neurogastronomija koja proučava način na koji mozak stvara percepciju okusa i kako stavlja hranu u službu emocija što je ujedno i predmet istraživanja ovog rada. Predmet završnog rada je definiranje odnosa hrane i emocija, odnosno proučavanje zakonitosti neurogastronomije kao još uvijek nedovoljno istražene znanstvene grane, ali i sve većeg trenda u gastronomiji. Osnovni cilj ovog rada je proučiti znanstvene aspekte gastronomije na temelju dosadašnjih istraživanja iz područja neurogastronomije i utvrditi značaj odnosa hrane i emocija. Metodom preglednog istraživanja sakupljene su informacije iz stručne literature koje u radu objašnjavaju pojmove i vrste emocija, percepciju hrane kroz osjetila te neurogastronomiju sa ciljem predočenja utjecaja hrane na emocionalno stanje pojedinca. Konačno, istražuje se primjena neurogastronomije u gastronomskom poslovanju uz prikaz primjera iz prakse.

Ključne riječi: neurogastronomija, emocije, hrana, osjetila, okusi



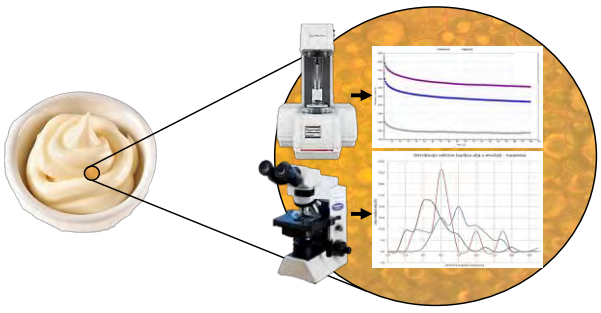
PROCJENA STABILNOSTI MAJONEZE – EMULZIJE NA BAZI ULJA
ASSESSMENT OF THE STABILITY OF MAYONNAISE – OIL-BASED EMULSION

Dora Brdar, Senka Šarić, Mihaela Antolić, Tihana Barić Dvorabić
Zvijezda plus d.o.o, Marijana Čavića 1, 10000 Zagreb

Stabilnost majoneze tj. mikrostruktura i međudjelovanje kapljica ulja u emulziji (tipa ulja u vodi) jedno je od ključnih karakteristika kvalitete gotovog proizvoda [1]. Stabilnost majoneze je u ovom istraživanju definirana dvjema metodama: distribucijom veličine kapljica ulja u emulziji te mjerenjem viskoznosti. Procjena stabilnosti i međusobne usporedivosti metoda određivana je na tri uzorka majoneze i tri uzorka salatne majoneze. Uzorci su proizvedeni na različitoj opremi korištenoj u procesu razvoja novog proizvoda, od pilot izrade do industrijske proizvodnje. Analizirani su uzorci proizvedeni na laboratorijskom homogenizatoru LH, (kapacitet 1 kg), pilot homogenizatoru PH (kapacitet 5 kg) i industrijskom homogenizatoru IH (kapacitet 500 kg). Cilj rada bio je usporediti korištene metode za određivanje stabilnosti te povezati stabilnost emulzije s proizvodnom opremom. Veličina kapljica ulja u emulzijama uzoraka izmjerena je mikroskopom Olympus CX41. Viskoznost je determinirana reometrom (Modular Compact Rheometer MCR 52, Anton Paar) sa koncentričnim cilindrom nazubljene površine (CC27S). Uzorci su pokazali ponašanje tipično za nenewtonovske pseudoplastične fluide pri konstantnoj smičnoj brzini 100 s^{-1} na sobnoj temperaturi (25 °C). U svim uzorcima povećanjem kapaciteta opreme i snage homogenizatora, od pilot opreme do industrijske opreme, rasla je i stabilnost emulzije. Porast stabilnosti emulzija očitovala se u porastu viskoznosti i smanjenju veličine kapljica ulja u emulziji što je u skladu s očekivanjem, a ovime je potvrđena i prihvatljivost upotrebe obje metode za analizu stabilnosti.

Ključne riječi: majoneza, stabilnost emulzije, distribucija veličine kapljica ulja, viskoznost

[1] M. Taslikh i sur., *J Food Sci Technol*. 59 (2022) 2108.



PRIMJENA UBRZANE EKSTRAKCIJE OTAPALIMA ZA IZOLACIJU BIOAKTIVNIH SPOJEVA IZ KOMINE BOROVNICE

UTILIZATION OF ACCELERATED SOLVENT EXTRACTION FOR THE RECOVERY OF BIOACTIVE COMPOUNDS FROM BLUEBERRY POMACE

Ena Cegledi, Erika Dobroslavić, Matea Rukavina,
Maja Repajić, Verica Dragović-Uzelac
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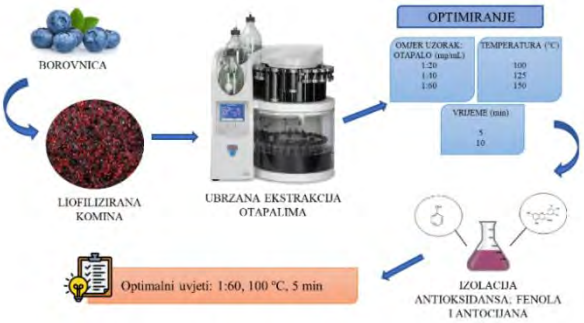
Nakon prerade borovnica, zaostala komina predstavlja vrijednu sirovinu bogatu antocijanima i fenolima poznatim po svojim antioksidativnim svojstvima i širokoj primjeni u prehrambenoj, kozmetičkoj i farmaceutskoj industriji. Napredne tehnike ekstrakcije, poput ubrzane ekstrakcije otapalima (ASE), koriste se kako bi se osigurali visoki prinosi i čistoća ekstrakta. Cilj ovog rada bio je optimirati uvjete ASE za efikasnu izolaciju fenola i antocijana iz komine borovnice te ispititati antioksidacijsku aktivnost ekstrakta FRAP metodom. Varirani parametri uključivali su omjer uzorak:otapalo (1:20, 1:40, 1:60 mg/mL), temperaturu (100, 125, 150 °C) te vrijeme ekstrakcije (5, 10 min). Statističkom obradom podataka zaključeno je da su optimalni uvjeti za učinkovitu ekstrakciju fenola i antocijana, kao i za visoku antioksidacijsku aktivnost ekstrakta komine borovnice, omjer uzorka i otapala 1:60 mg/mL, temperatura 100 °C i vrijeme ekstrakcije od 5 minuta. Primjena ASE omogućuje bolje iskorištavanje komine, podržavajući održivost i ekonomsku isplativost proizvodnje te pružajući visokokvalitetne ekstrakte za razne industrije.

Ključne riječi: komina borovnice, ubrzana ekstrakcija otapalima, fenoli, antocijani



KORELACIJA UDJELA ČVRSTIH TRIGLICERIDA I REOLOŠKIH SVOJSTAVA SMJESA BILJNIH MASTI I ULJA PRI 25 °C I 30 °C

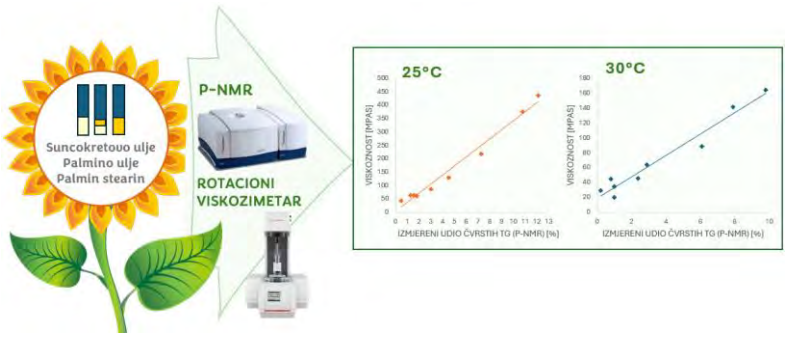
CORRELATION OF SOLID FAT CONTENT AND RHEOLOGICAL PROPERTIES OF VEGETABLE FATS AND OILS MIXTURES AT 25 °C AND 30 °C

Amanda Dorner, Zvonimir Ladešić, Juraj Tonković
Zvijezda Plus d.o.o., Marijana Čavića 1, 10000 Zagreb

Funkcionalnost masti u hrani određena je ukupnom količinom kristaliziranih masti, mjereno kao udio čvrstih triglicerida (SFC) [1]. U industrijskim uvjetima je viskoznost masti i ulja pri određenim temperaturama jedan od ključnih čimbenika koje je potrebno uzeti u obzir prilikom projektiranja, planiranja i provedbe tehnoloških procesa [2].
Cilj ovog rada bio je utvrditi postoji li korelacija između navedenih fizikalnih svojstava masne smjese. Pripremljene su binarne i ternarne smjese ulja i masne sirovine različitog sastava (suncokretovo ulje, palmin stearin, palmino ulje) u poznatim omjerima. Postotak mase triglicerida u čvrstom stanju izmjeren je impulsnom nuklearnom magnetskom rezonancijom (p-NMR) pri 25 °C i 30 °C. Dinamička viskoznost je određena rotacionim viskozimetrom (Modular Compact Rheometer MCR 52, Anton-a Paar) sa koncentričnim cilindrom nazubljene površine (CC27S) pri istim temperaturama. Kako se radi o newtonovskom fluidu, viskoznost pri datoj temperaturi je konstantna, te je prikazana međuovisnost promjenjivih varijabli [2]. Uočen je trend linearnog rasta viskoznosti [mPas] s porastom udjela čvrstih triglicerida [%] pri 25 °C i 30 °C, uz R^2 vrijednosti 0,98 (25 °C) i 0,96 (30 °C).

Ključne riječi: reologija, viskoznost, rotacioni viskozimetar, p-NMR, SFC

[1] M. Teles dos Santos i sur., *J. Food Eng*. 126 (2014) 198-205.
[2] B. E. Rapp, Microfluidics: Modeling, Mechanics and Mathematics, Elsevier, 2017, str. 243-263.



OPTIMIZATION OF MICROWAVE-ASSISTED EXTRACTION OF PECTIN FROM TOMATO POMACE

Nikolina Golub[1], Dubravka Vitali Čepo[1], Emerik Galić[1], Kristina Radić[1], Ilija Djekic[2], Nada Smigic[2]

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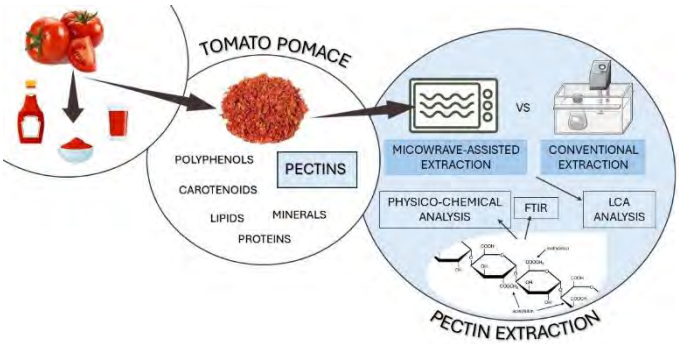
[2]*University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Beograd*

Tomato is one of the most produced vegetables in the world. Its processing into sauce, paste, juice and other food products, creates a substantial amount of waste in the form of tomato pomace, primarily composed of tomato peel, seeds and small amounts of pulp. Despite being rich in bioactive compounds with significant potential for creating value-added products, tomato pomace is typically discarded in landfills or used as livestock feed and fertilizer. One of the valuable functional ingredients that can be extracted from tomato pomace is pectin, a cell wall polysaccharide with galacturonic acid backbone which can be methylesterfied and acetylated. Its functionality depends on molecular size and degree of methoxylation, which may vary depending on the source and extraction conditions. In this research we optimized microwave-assisted extraction (MAE) of pectin from tomato pomace using citric acid as solvent. Response surface methodology using the central composite design was used to model the optimization process. The physico-chemical properties (equivalent mass, methoxyl content, degree of esterification, galacturonic acid content) were determined using titrimetric methods, yield was determined gravimetrically, and the structure was characterized by FTIR spectroscopy. Life Cycle Assessment (LCA) was applied to assess the environmental impact of MAE and conventional water bath extraction (CE). Optimal microwave conditions (12 min/600 W/pH 1) yielded two times more pectin than CE (2 h/85 °C/pH 1.5). Results suggest that MAE can be used as an efficient method for pectin extraction from tomato pomace.

Keywords: tomato pomace, microwave-assisted extraction, pectin



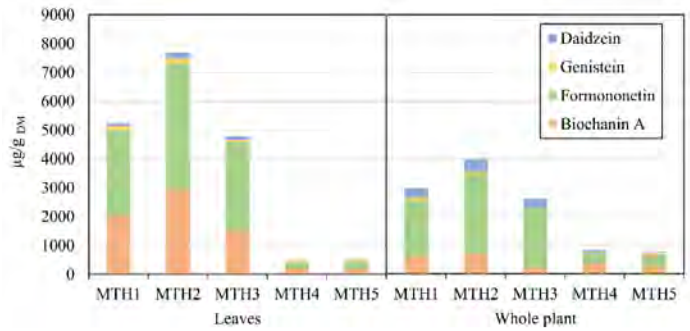
AN IMPROVED MICROSCALE METHOD FOR EXTRACTION OF ISOFLAVONES FROM RED CLOVER (*Trifolium pratense* L.)

Marija Kovačević Babić, Marija Viljevac Vuletić, Daniela Horvat
Agricultural Institute Osijek, Južno predgrađe 17, 31000 Osijek

Red clover (*Trifolium pratense* L.) is a widely used fodder, but in the past decade has attracted interest as an alternative valuable source of isoflavones with variety of health protective effects. Legumes Isoflavones are present in different chemical forms, but their health beneficial effects are most pronounced in their free forms—aglycones. The main aim of this study was to obtain the highest content of isoflavones from red clover leaves and whole plant through the various extraction and hydrolysis methods. Briefly, 0.05 g of the powder sample was dissolved in 10 mL of 100% methanol – water mixture (50 : 50) using 2 M HCl (MTH1), 2M HCl with evaporation to dryness (MTH2), 6M HCl (MTH3), as well as by 80% MeOH without (MTH4) and with evaporation of extract to dryness (MTH5). The extracts were analysed by HPLC (High-Performance Liquid Chromatography) using an external calibration curve for isoflavones quantification. The highest concentration of total isoflavones was obtained from the leaf extract that was evaporated to dryness after 2M HCl hydrolysis as follows: formononetin 4358.75 µg/g_{DM}, biochanin A 2950.23 µg/g_{DM}, daidzein 186.98 µg/g_{DM} and genistein 194.09 µg/g_{DM}, while in whole plant a lower values of isoflavones were obtained, except for daidzein, as follows: formononetin 2746.17 µg/g_{DM}, biochanin A 731.41 µg/g_{DM}, daidzein 428.93 µg/g_{DM} and genistein 81.16 µg/g_{DM}.

Keywords: red clover, extraction, isoflavones, HPLC

This study was financially supported by internal competitive research project “Legumes as a source of biologically active phytochemicals” of the Agricultural Institute Osijek.



Concentration of individual isoflavones (µg/g_{DM}) in red clover leaf and whole plant in five different extraction methods (MTH1, MTH2, MTH3, MTH4, MTH5)

CONSUMER EXPOSURE ASSESMENT TO CYCLOPIAZONIC ACID FROM CROATIAN DRY-FERMENTED MEAT PRODUCTS

Tina Lešić[1], Ana Vulić[1], Nina Kudumija[1], Brigita Hengl[2], Nada Vahčić[3], Jelka Pleadin[1]

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[2]*Croatian Food Agency for Agriculture and Food, Center for Food Safety, Ivana Gundulića 36b, 31000 Osijek*
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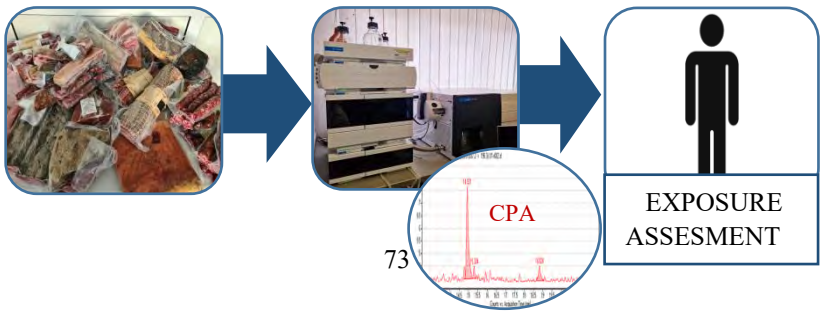
There is limited data on the toxicity of the mycotoxin cyclopiazonic acid (CPA) and its occurrence in various foods. CPA has been shown to be present in high concentrations in dry-fermented meat products, mainly as a product of moulds that overgrow the surface of these products during maturation. The aim of this study was to assess human exposure to CPA by analysing 288 samples of dry-fermented meat products available on the market in relation to the consumption data of Croatian citizens. CPA was analysed using the liquid chromatography-tandem mass spectrometry (LC-MS/MS) method, achieving a limit of detection (LOD) of 2.17 µg/kg. The CPA concentrations above LOD were found in 40 out of 288 samples. The average result was determined using the "lower bound" (LB), "middle bound" (MB) and "upper bound" (UB) scenarios because of cases when result was lower than LOD. For the exposure assessment, the average CPA contamination of TMP was used and compared with the amount of TMP consumed for all three scenarios. The calculated daily body weight exposure for the LB, MB and UB scenarios was 1.52, 1.98 and 2.43 ng/kg, respectively. The European Food Safety Authority (EFSA) has not yet established a health-based guideline value (HBGV) for the consumer risk associated with CPA in food and CPA has not yet been classified by the International Agency for Research on Cancer (IARC) as the carcinogenicity studies are not sufficiently conclusive. Among the meat product categories, dry-fermented sausages contribute the most to consumer exposure. CPA occurence should be monitored over a longer period of time in order to observe the trend of human exposure, as their occurrence in these products depends on different factors such as weather conditions.

Keywords: mycotoxins, sausages, consumption data, dietary exposure, risk assessment



BILJNI NAPITCI ALTERNATIVA MLIJEKU: NUTRITIVNA I FUNKCIONALNA SVOJSTVA

PLANT-BASED MILKS: NUTRITIONAL AND FUNCTIONAL PROPERTIES

Bojan Matijević

Veleučilište u Karlovcu, Trg J.J. Strossmayera 9, 47000 Karlovac

Biljni napitci kao alternativa mlijeku su proizvodi koji posljednjih godina bilježe značajan porast prodaje, ali i velika ulaganja u razvoj. Procjenjuje se da će tržište ove vrste proizvoda u narednih 6 godina rasti za 9,3 %. Trend rasta tržišta biljnih napitaka posljedica je porasta svijesti populacije o prehrani, ali glavni razlog konzumacije zdravstvene je prirode. Naime, mlijeko je vrijedan izvor hranjivih tvari i mikronutrijenata, ali određenom broju ljudi stvaraju zdravstvene smetnje kao što je intolerancija na laktozu i alergija na proteine te se oni okreću biljnim napitcima [1]. Nutritivna vrijednost mlijeka i biljnih alternativa uvelike se razlikuje tako da proizvođači obogaćuju svoje biljne napitke. Tehnološki postupak proizvodnje također se razlikuje od sirovine do sirovine [2]. Na našem tržištu zastupljeni su biljni napitci iz soje, badema, zobi, riže i kokosa. Rad ima za cilj opisati nutritivni i funkcionalna svojstva biljnih napitaka kao alternative mlijeku, te prednosti i nedostatke konzumacije u usporedbi s kravljim mlijekom.

Ključne riječi: alternativa mlijeku, biljni napitci, nutritivna vrijednost, funkcionalna svojstva

[1] M. Kem, *J. Food Process. Technol.* 13 (8) (2022) 1000949.
[2] E.F. Aydara, S. Tutuncua, B. Ozcelika, *J. Fun. Foods* 70 (2020) 103975.

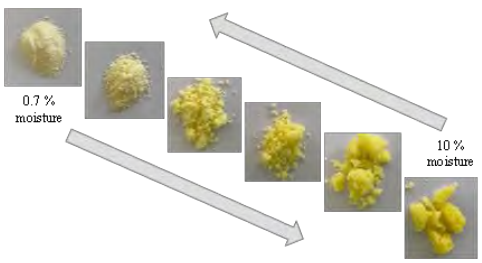
EVALUATING THE IMPACT OF MOISTURE ON MULTIVITAMIN INSTANT GRANULES USING NIR SPECTROSCOPY AND CHEMOMETRICS

Nika Morača, Martina Ćosić, Ana Jurinjak Tušek, Davor Valinger, Jasenka Gajdoš Kljusurić, Tamara Jurina, Maja Benković

University of Zagreb Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000 Zagreb

Instant food powders obtained by agglomeration are increasingly popular on the market, primarily due to their excellent reconstitution properties. Among them, multivitamin powders are an important source of different types of vitamins for human body, as they are practical and have alluring appearance and taste. This study investigated how moisture content affects the physical properties and near-infrared (NIR) spectra of multivitamin instant powders. The powders were adjusted to different moisture levels (1, 2, 3, 4, 6, 8, and 10 grams per 100 grams) and then analyzed. For each moisture level, the following properties were measured: moisture content, water activity (a_w), color, particle size distribution, bulk density, reconstitution properties, and the Hausner ratio. NIR spectra were also recorded. Chemometric techniques (Partial Component Analysis (PCA) and Partial Least Squares models (PLS)) were used to find relationships between moisture content and the observed properties. The results showed that as the moisture content increased, the flow properties of the powders worsened (based on bulk density and Hausner ratio). Also, the ability of the powder to disperse in water decreased with higher moisture content. Moisture content was also found to affect the color, particle size, and water activity of the samples. It also caused changes in the NIR spectra, which could be successfully analyzed using chemometrics. The developed PLS models showed excellent fit between experimental and model derived data for L^* (R^2 = 0.827), b^* (R^2 = 0.843), Chroma (R^2 = 0.843), ΔE (R^2 = 0.872) and moisture content (R^2 = 0.842), while they were less successful in predicting the values of a^* (R^2 = 0.236), hue (R^2 = 0.122) and a_w (R^2 = 0.683).

Keywords: multivitamin powders, flow properties, color, water activity, chemometrics



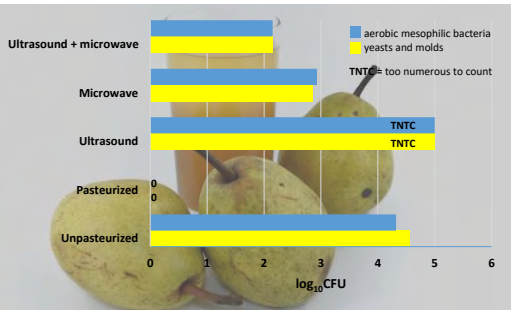
THE IMPACT OF MINIMAL PROCESSING AND PASTEURIZATION ON THE AROMATIC PROFILE AND MICROBIOLOGICAL QUALITY OF PEAR NECTAR

Nela Nedić Tiban, Anita Pichler, Ivana Ivić, Ivona Bjelobrk, Marijana Oršolić, Hrvoje Pavlović

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

Although our autochthonous or domesticated pear varieties often do not look very attractive, they provide products with specific sensory properties and a particularly pronounced aroma. The aim of the study was to investigate the effects of minimal processing and pasteurization on the aromatic profile of pear nectars of the traditional Miholjača variety. The processing and preservation of pear nectars included pasteurization as a conventional technique and minimal processing: ultrasound, microwave treatment and the combination of microwaves and ultrasound. The microbiological quality of the pear nectars during a 30-day storage at 4 ºC was also evaluated. The microbiological criteria of control (untreated) and treated samples (aerobic mesophilic bacteria, *Salmonella*, *Enterobacteriaceae*, sulfite-reducing clostridia, and molds and yeasts) were determined according to the Guidelines for Microbiological Criteria of Food. Twenty-seven compounds were determined in the control nectar by gas chromatography-mass spectrometry (GC/MS) and SPME sampling methods, which were categorized into carbonyl compounds, terpenes and esters. Minimal processing resulted in an increase or retention of aroma compounds, while in the pasteurized sample decline in the total content in all groups of compounds was observed. The use of pasteurization, microwaves and a combination of ultrasound and microwaves proved to be the most effective in preserving the microbiological quality of pear nectars, while the use of ultrasound was the least effective in reducing the number of aerobic mesophilic bacteria, and molds and yeasts. *Salmonella* and *Enterobacteriaceae* were not detected in any of analyzed sample.

Keywords: pear, Miholjača, nectar, aroma, microbiological quality



FORMULATION OF ALGINATE-BASED DELIVERY SYSTEMS ENRICHED WITH GROUND IVY (*Glechoma hederacea* L.) POLYPHENOLIC EXTRACT BY ELECTROSTATIC EXTRUSION

Danijela Šeremet, Ivana Žepić, Ana Mandura Jarić, Aleksandra Vojvodić Cebin, Draženka Komes

University of Zagreb Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000 Zagreb

Ground ivy (*Glechoma hederacea* L.) belongs to the Lamiaceae family and is widespread in Europe, America and Asia, where it has been used for generations in traditional medicine to treat various diseases. On the other side, the chemical and bioactive composition of ground ivy is still understudied and among the few studies, the presence of phenolic compounds, such as rosmarinic, caffeic, chlorogenic acid, rutin, etc., has been reported. The aim of the present study was to formulate encapsulation delivery systems of ground ivy polyphenolic extract by electrostatic extrusion. Sodium alginate was used as a base (75% of dry matter of delivery solution) for binary carrier solutions (4%) in combination with collagen hydrolysates, carboxymethyl cellulose and nutriose. The bioactive characterization of the obtained alginate-based beads included the determination of the encapsulation efficiency of total phenols and hydroxycinnamic acids by spectrophotometric methods, as well as individual phenolic compounds by HPLC-PDA methodology. Additionally, the release kinetics of total phenols in fluids simulating the gastric and intestinal phases were performed. The highest encapsulation efficiency of 74.76 and 72.49 % for total phenols and hydroxycinnamic acids, respectively, was obtained by combining sodium alginate with carboxymethyl cellulose, while their controlled and continuous release during simulated digestion was observed in all samples.

Keywords: electrostatic extrusion, encapsulation, ground ivy, polyphenols

This work has been supported by Croatian Science Foundation through the project IP-2019-045879.

THE ANTIOXIDATING EFFECT OF POLYPHENOLS FROM APPLE JUICE DETERMINED USING AN ELECTROCHEMICAL BIOSENSOR

Ivana Tomac[1], Ana-Marija Gotal Skoko[1], Ivana Flanjak[1], Antun Jozinović[1], Goran Fruk[2], Marin Mihaljević Žulj[2], Ante Lončarić[1]

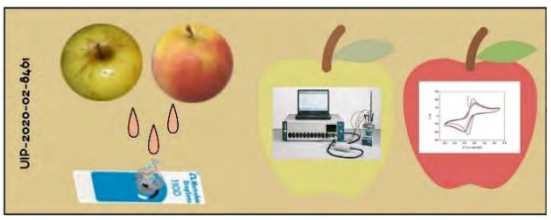
[1]*Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek*

[2]*University of Zagreb Faculty of Agriculture, Svetošimunska 25, 10000 Zagreb*

An electrochemical biosensor was applied to determine the juice polyphenols antioxidant effect of 10 traditional and 5 commercial apple cultivars. DNA was used as a biologically active sensor component and cyclic voltammetry as an instrumental technique. The antioxidant effect was monitored over two years every three months in the apple juice extracts. The results have demonstrated that the addition of apple juice extracts from both, traditional and commercial apple cultivars, to the cleavage solution reduces the degree of DNA degradation and shows a portion of survived DNA as follows: 43.23 – 94.99 % (the 1st year of the research) and 57.85 – 94.11 % (the 2nd year of the research). 'Mašenka', 'Kanadska Reneta' and 'Ilzer Rosenapfel' extracts of traditional apple cultivars and 'Jonagold' and 'Fuji' extracts of the commercial apple cultivars had the best antioxidant effect on the surviving DNA. From this research could be concluded that juice from traditional apple cultivars has a better antioxidant effect on the portion of survived DNA (69-87 %) in comparison to juice from commercial apple cultivars (67-85 %). These results are probably a reflection of the polyphenol profile of the examined cultivars.

Keywords: apple juice, polyphenols, antioxidant effect, electrochemical biosensor

This research was funded by the Croatian Science Foundation (UIP-2020-02-8461).



USPOREDBA OKSIDATIVNE STABILNOSTI JESTIVIH BILJNIH ULJA

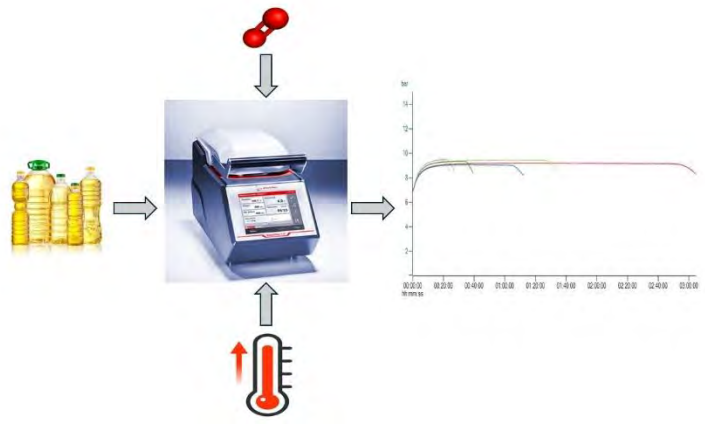
COMPARISON OF THE STABILITY OF EDIBLE VEGETABLE OILS

Juraj Tonković, Sandra Maričić Tarandek, Karlo Würth
Zvijezda plus d.o.o., Marijana Čavića 1, 10000 Zagreb

Oksidativna stabilnost kao jedna od najvažnijih karakteristika kvalitete jestivih biljnih ulja je otpornost na reakciju oksidacije. Oksidacija je odgovorna za smanjenje kvalitete jestivih ulja zbog kvarenja okusa, mirisa i boje, a rezultira užeglošću. Inicijalni korak oksidacije ulja je adicija kisika na dvostruke veze u lancu masne kiseline pri čemu nastaje nestabilni spoj peroksid. Proučavanje tijeka oksidacije ulja prati se količinom kisika koji se apsorbira od strane ulja. Brzina oksidacije ovisi o temperaturi, količini dostupnog kisika, prisutnosti metala, svjetlosti i sastavu masnih kiselina ulja [1].
Cilj rada bio je usporediti oksidativnu stabilnost različitih vrsta jestivih biljnih ulja i utjecaj temperature na oksidativnu stabilnost ulja. U eksperimentu su korištena sljedeća ulja: suncokretovo ulje, visoko oleinsko suncokretovo ulje, repičino ulje, ekstra djevičansko maslinovo ulje i omegol ulje (mješavina repičinog i suncokretovog ulja). Eksperimenti su rađeni na uređaju Rapidoxy 100. Mjereno je vrijeme potrebno da dođe do početka oksidacije ulja – indukcijski period, odnosno da tlak kisika u posudi s uzorkom padne za 10 % od početne vrijednosti. Ulja koja su imala veći udio zasićenih masnih kiselina u svom sastavu pokazala su veću oksidativnu stabilnost u odnosu na ulja koja su bogata nezasićenim masnim kiselinama.

Ključne riječi: biljna ulja, oksidativna stabilnost, oxytest

[1] Y. H. Hui, Bailey´s industrial oil and fat products-5th Edition, J. Wiley & Sons, New York, 1996, str. 411-415.



VALORIZATION POTENTIAL OF ITALIAN RYEGRASS AND REED CANARYGRASS BASED ON PROXIMATE, CARBOHYDRATE AND PHENOLICS COMPOSITION

Aleksandra Vojvodić Cebin[1], Danijela Šeremet[1], Ana Mandura Jarić[1], Cléa Normand-Dubeau[2], Solenn Eude[3], Draženka Komes[1]

[1]*University of Zagreb Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000 Zagreb*

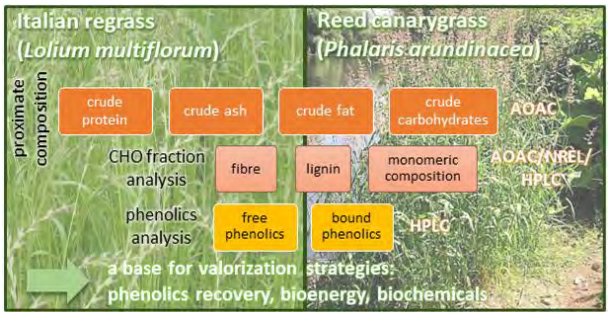
[2]*Institute Agro Dijon, 26 Boulevard du Docteur Petitjean, 21000 Dijon, France*

[3]*Polytech Clermont Campus Universitaires des Cézeaux, 2 Av. Blaise Pascal, 63000 Aubière, France*

Italian ryegrass (*Lolium multiflorum*, IRG) and reed canarygrass (*Phalaris arundinacea*, RCG) are plant species within the Poaceae family, mainly cultivated for animal feed. Biomass of both species can be characterized as lignocellulose. Recently, these materials are increasingly being investigated for their valorization potential as novel industrial feedstocks, primarily for the production of bioenergy and biochemicals. The recovery of initially present bioactive compounds (phenolics) is still understudied. The aim of this work to set a base for determining valorization strategies of IRG and RCG in terms of proximate composition, with special emphasis on the carbohydrate fraction, and the content of phenolics. Proximate composition included dry matter-based crude protein, fat, ash and carbohydrate contents, while the carbohydrate fraction was further analysed for fibre, lignin and monomeric composition. Free and bound phenolic compounds were determined with Folin-Ciocalteu reaction and individually by HPLC-DAD. This study presents a valuable reference work, especially for the characterization of phenolics.

Keywords: carbohydrates, Italian ryegrass, phenolics, proximate composition, reed canarygrass, valorization

This work has been supported by Croatian Science Foundation through the project IP-2022-10-3075.



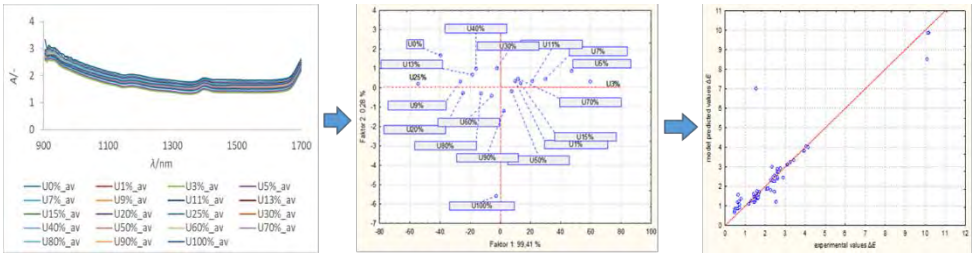
DETECTION OF ADULTERATION OF GROUND COFFEE USING NEAR-INFRARED SPECTROSCOPY AND CHEMOMETRICS

Antonia Zeman, Manuela Panić, Davor Valinger, Ana Jurinjak Tušek, Jasenka Gajdoš Kljusurić, Maja Benković, Tamara Jurina

University of Zagreb Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000 Zagreb

Coffee authenticity has become a challenging issue in the food industry, due to the fact that coffee is among the most consumed beverages globally. When considering coffee's market value, the main problem represents an illegal practice of adulterating coffee with less expensive and inferior ingredients, due to greater financial profit. Therefore, the purpose of this work was to investigate if Near Infrared Spectroscopy (NIRs), in combination with chemometrics, could be used in detection of the adulteration of ground coffee with malt coffee. Pure coffee samples were adulterated with corresponding amounts of malt coffee and prepared mixtures (1%, 3%, 5%, 7%, 9%, 11%, 13%, 15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%) were recorded using two NIRs devices. Principal Component Analysis (PCA) successfully distinguished prepared mixtures with the eigenvalues of 99.41% and 0.28% for the first and second factor, respectively. Based on the recorded NIR spectra, artificial neural network models (ANNs) were developed in order to predict physical (dry matter content, color change, average Feret's particle diameter) and chemical (concentration of caffeine measured by two methods: spectrophotometric and HPLC) characteristics of the adulterated samples. The developed ANN models, with values of $R^2_{validation}$ = 0.8088 – 0.9659 for caffeine concentration of the prepared mixtures and values of $R^2_{validation}$ = 0.7471 – 0.9791 for color change (ΔE), showed the potential for industrial application of NIRs in detection of adulteration of ground coffee.

Keywords: Near Infrared Spectroscopy, chemometrics, artificial neural networks, ground coffee



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MEDICINSKA KEMIJA I FARMACIJA
MEDICAL CHEMISTRY AND PHARMACY

ODREĐIVANJE SADRŽAJA VODE U HIGROSKOPNIM PRAŠKASTIM FARMACEUTSKIM PROIZVODIMA UPOTREBOM KARL FISCHER KULOMETRA S PEĆNICOM

WATER CONTENT DETERMINATION IN HYGROSCOPIC POWDER PHARMACEUTICAL PRODUCTS USING KARL FISCHER COULOMETER WITH OVEN

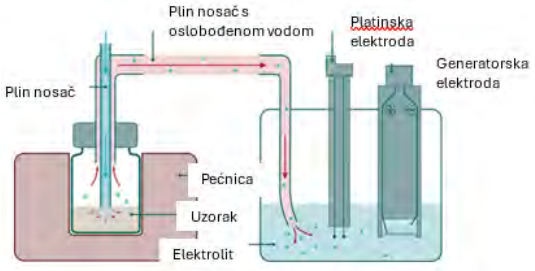
Barbara Debanić

Pliva Hrvatska d.o.o., Teva grupa, Istraživanje i razvoj,
Prilaz baruna Filipovića 25, 10000 Zagreb

Određivanje sadržaja vode u farmaceutskim proizvodima važno je kako bi se dokazala sukladnost s farmakopejskim zahtjevima [1]. Također, sadržaj vode ima direktan utjecaj na stabilnost i kvalitetu proizvoda. Jedna od tehnika kojom se kvantitativno može odrediti sadržaj vode u praškastim uzorcima je kulometrijsko određivanje sadržaja vode metodom po Karl Fischeru (KF). Mjerenje se odvija u mjernoj ćeliji koja se sastoji od generatorske elektrode (anode) i platinske elektrode (katode). Prilikom prolaska električne struje kroz mjernu ćeliju ispunjenu elektroliom, jodidni ioni iz elektrolitne otopine oksidiraju se na anodi u jod koji kvantitativno reagira s vodom koja je prisutna u uzorku. Završetak reakcije određuje se voltametrijski, mjerenjem napona između dvostruke platinske elektrode, koji se značajno smanjuje prisutnošću slobodnoga joda [1,2]. Određivanje sadržaja vode u higroskopnim praškastim uzorcima može predstavljati izazov. Kombinacija KF kulometra s pećnicom, kulometrijske Karl Fischer titracije te upotreba izolatora s kontroliranim uvjetima relativne vlažnosti, uvelike može olakšati određivanje sadržaja vode u uzorcima u kojima je to otežano. U ovome radu će biti prikazano kako rukovanje higroskopnim praškastim uzorcima može utjecati na točnost i preciznost metode za određivanje sadržaja vode.

Ključne riječi: Karl Fischer, sadržaj vode, kulometar s pećnicom, higroskopan uzorak

[1] United States Pharmacopeia (2024) General Chapter, ⟨921⟩ Water Determination.
[2] Metrohm Monograph 8.026.5013 - Water Determination by Karl Fischer Titration.



THE EFFECT OF COPPER(II) COCRYSTAL WITH HETEROCYCLIC LIGANDS ON THE VIABILITY OF THE Caco-2 CELL LINE

Nikolina Filipović[1], Tomislav Balić[1], Martina Medvidović-Kosanović[1], Dominik Goman[1], Berislav Marković[2], Sunčica Roca[3], Stjepan Šarić[1], Ivana Jelavić[4], Katarina Mišković Špoljarić[4]

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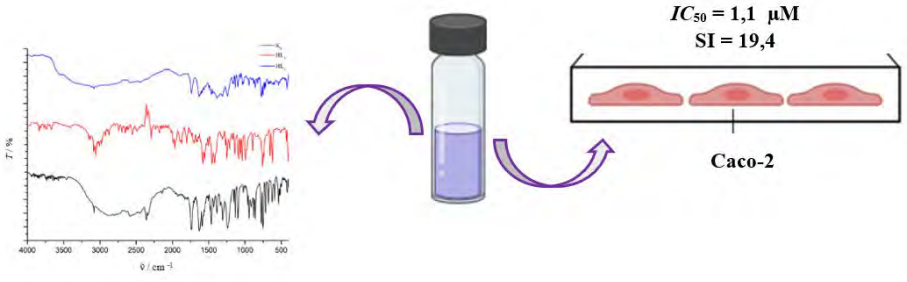
Over the last decade, cocrystals have attracted the interest of scientists, as a long-known but little-studied class of crystalline solids, and are now an integral part of the preformulation phase of drug development [1]. In this study, a copper(II) cocrystal was prepared with chromone-2-carboxylic acid and 2,2′-bipyridine. This mixture of two ligands yielded a compound highly specific for the Caco-2 cell line, inhibiting it by 94.8% ($p < 0.0001$) at a concentration of 10^{-5} mol dm^{-3} and by 81.3 ($p < 0.0001$) at a concentration of 10^{-6} mol dm^{-3}. To confirm the biological activity of the compound, the values of IC_{50} (inhibitory concentration; 1.1 μM) and selectivity index (SI = 19.4) were calculated, indicating significant cytotoxicity and selectivity of the compound. The information obtained in this research may contribute to the development of new, highly selective compounds.

Keywords: citotoxicity, cocrystals, heterocyclic compounds, viability

[1] N.K. Duggirala, M.L. Perry, Ö. Almarsson, M.J. Zaworotko, *Chem. Commun.* 52 (2016) 640–655.



SYNTHESIS AND BIOLOGICAL ACTIVITY OF NEW BENZOXAZOLES AS pH SENSORS

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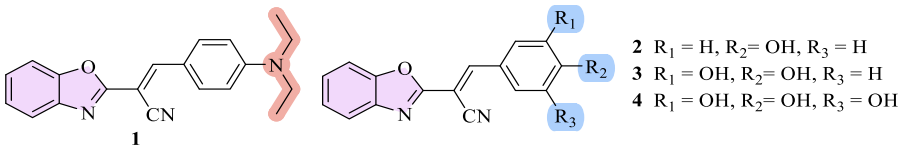
Benzoxazole has been incorporated as an essential pharmacophore and substructure in the structure of various medicinally important compounds, offering a range of biological and pharmacological activities such as, anticancer, antiviral, antibacterial, antimicrobial and others [1,2]. This paper presents the synthesis, biological evaluation and spectroscopic characterization of acrylonitrile derived benzoxazoles prepared by aldol condensation from benzaldehyde and 2-cyanomethylbenzoxazole in water. Antiproliferative activity *in vitro* was evaluated on the several human cancer cells while the antibacterial activity *in vitro* was tested on a Gram-positive and Gram-negative bacterial strains. Additionally, spectroscopic characterization and pH spectroscopic titrations were performed in order to determine possible application of chosen compounds as pH sensors in solutions followed by determination of p*K*a values experimentally as well as computationally.

Keywords: benzoxazole, acrylonitrile, biological activity, pH sensors

[1] X. K. Wong, K. Y. Yeong, *ChemMedChem* 16 (2021) 3237–3262.
[2] A. Abdullahi, K. Y. Yeong, *Med. Chem. Res.* 33 (2024) 406–438.

The Croatian Science Foundation funded this work (project HRZZ-IP-2020-02-8090).



PREDUVJETI ZA ANALIZU METAL-EDTA KOMPLEKSA TEKUĆINSKOM KROMATOGRAFIJOM

PREREQUISITES FOR THE ANALYSIS OF METAL-EDTA COMPLEX USING LIQUID CHROMATOGRAPHY

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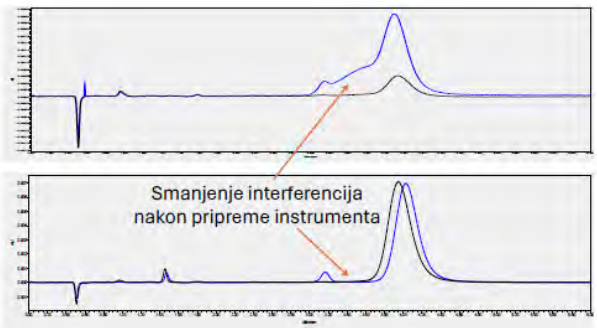
Analiza metalnih iona u farmaceutskim proizvodima može biti izazovna pogotovo kada je potreban korak njihovog kompleksiranja s odgovarajućim agensom. Jedan od takvih agensa je etilendiamintetraoctena kiselina (EDTA) koja može vezati ione metala kao što su Mg^{2+}, Cu^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+} i Zn^{2+}[1]. Kako bismo mogli analizirati ione metala tekućinskom kromatografijom potrebno ih je vezati za spoj koji će imati svojstvo zadržavanja na kromatografskoj koloni, a upravo jedan od tih spojeva može biti EDTA. EDTA ima sposobnost prioritetnog vezanja određenih iona metala ovisno o pH otopine u kojoj se nalazi, što uvelike olakšava selektivnost samog kompleksiranja. Tako pripremljeni kompleks može se analizirati tekućinskom kromatografijom, međutim, sam instrument izrađen je od metalnih dijelova, pri čemu EDTA iz pripremljenog uzorka može dodatno vezati slobodne ione metala iz uređaja, što može dovesti do netočnih i nepouzdanih rezultata.
U ovom radu prikazat će se mogući utjecaji slobodnih iona metala na kromatografiju u analizi metal-EDTA kompleksa te kako ispiranje instrumenta s odgovarajućim otopinama može smanjiti njihov utjecaj.

Ključne riječi: ioni metala, EDTA, kromatografija

[1] R. Nkuna, G. N. Ijoma, T. S. Matambo, *J. Fungi*. 8 (2022) 419.



HEAVY METALS IN SLIPPERY ELM DIETARY SUPPLEMENTS

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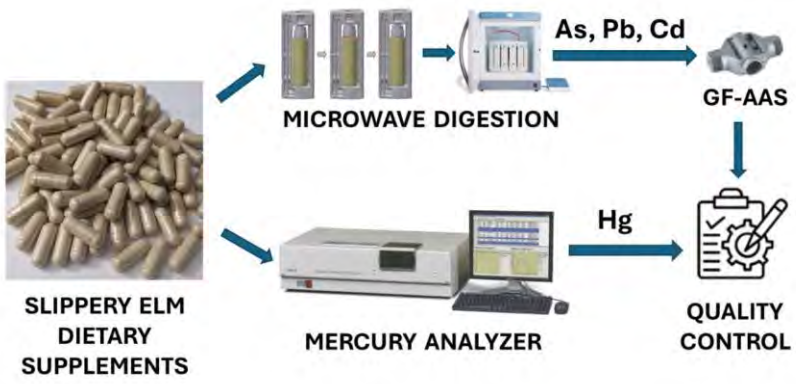
The quality issues associated with dietary supplements have received steady warnings from the scientific and healthcare communities. Risks include the presence of harmful agents such as metal impurities. In traditional medicine, dietary supplements containing slippery elm (*Ulmus rubra*), also known as red elm, are used orally to treat gastrointestinal and urinary tract disorders and topically for skin diseases. For this reason, the purpose of this study was to evaluate the content of heavy metal impurities (As, Cd, Pb, and Hg) in slippery elm-containing formulated dietary supplement products. The results indicate the necessity for continuous monitoring of heavy metal impurities in these types of samples.

Keywords: heavy metals, metal impurity, slippery elm, dietary supplements, quality control



MEHANOKEMIJSKI POSTUPAK PRVOG STUPNJA SINTEZE DEFERASIROKSA

MECHANOCHEMICAL PROCEDURE OF THE FIRST STAGE OF DEFERASIROX SYNTHESIS

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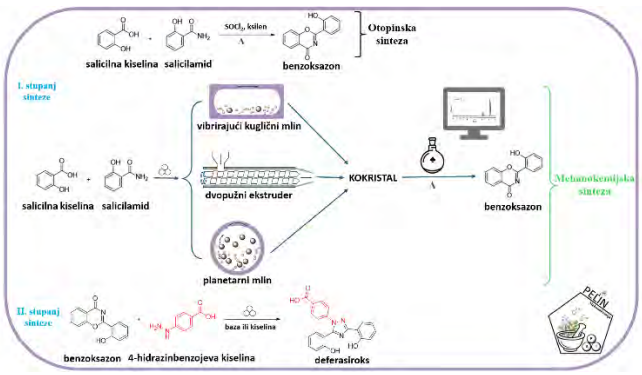
Mehanokemija je grana kemije koja uključuje kemijske i fizikalno-kemijske transformacije tvari, svih agregatnih stanja, potaknute mehaničkom energijom. IUPAC je mehanokemiju uvrstio u jednu od deset tehnologija budućnosti koja će revolucionirati svijet. Slijedi načela zelene kemije i nalazi široku primjenu, posebice u anorganskoj kemiji i kemiji materijala, a u novije vrijeme i organskoj te farmaceutskoj kemiji.

Cilj istraživanja bio je sintetizirati djelatnu tvar – deferasiroks. To je prvi oralni kelator željeza koji se najčešće koristi za uklanjanje viška željeza iz tijela. Zbog povoljne ekonomije atoma, izvrstan je kandidat za pokušaj mehanokemijske sinteze. U radu je opisan mehanokemijski postupak prvog stupnja sinteze. Kao glavnu razliku u odnosu na konvencionalni pristup važno je istaknuti izbjegavanje korištenja opasnih i korozivnih sredstava. Dokazano je da je benzoksazon (produkt prvog stupnja) moguće sintetizirati bez korištenja otopala i to u većem prinosu od uobičajene sinteze. Provedeni eksperimenti rezultirali su i otkrićem novog kokristala salicilne kiseline i salicilamida. Poboljšanjem procesa, odnosno dodatnim optimiranjem najvjerojatnije bi se moglo postići još veće iskorištenje. Drugi stupanj treba pokušati provesti, a postoji velika mogućnost za uspješnost i ovog stupnja jer su njegovi reakcijski uvjeti blaži od onih u prvom stupnju.

Ključne riječi: mehanokemija, zelena kemija, kokristali, benzoksazon, deferasiroks



ANTIOXIDANT ACTIVITY OF THE AQUEOUS EXTRACTS OF WILD THYME, DALMATIAN SAGE AND THEIR MIXTURE

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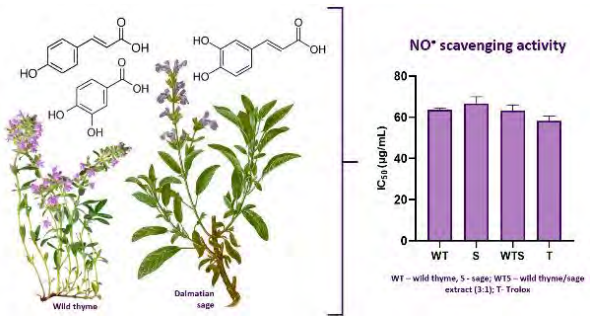
Medicinal and aromatic plants are a rich source of bioactive compounds with antioxidant effects. Wild thyme (*Thymus serpyllum* L.), Dalmatian sage (*Salvia officinalis* L.) and their two-component mixture (3:1) showed the highest content of total polyphenols in our previous study and could be used in the development of functional beverages [1]. Therefore, the aim of this study was to evaluate the antioxidant activity of their freeze-dried aqueous extracts using the DPPH and NO radical scavenging, reducing power and iron chelation assays in comparison to reference antioxidants. All tested extracts showed the ability to scavenge DPPH and NO radicals. The sage extract proved to be the best scavenger of DPPH radicals (IC_{50} = 3.27 µg/mL), while there was no significant difference in the ability to scavenge NO radicals (IC_{50} = 63.38-66.81 µg/mL). Compared to the sage extract, the wild thyme extract had a better ability to reduce and chelate iron ions, with IC_{50} values of 30.57 µg/mL and 375.05 µg/mL, respectively. Our results show that the aqueous extracts of wild thyme and sage are potent antioxidants with a multitarget mechanism of action and their mixture in a 3:1 ratio does not lead to an increase in antioxidant properties.

Keywords: wild thyme, Dalmatian sage, antioxidant activity

[1] I. Maleš, V. Dragović-Uzelac, I. Jerković, Z. Zorić, S. Pedisić, M. Repajić, I. Elez Garofulić, A. Dobrinčić, *Antioxidants* 11 (2022) 1140.



FIZIKALNO-KEMIJSKA KARAKTERIZACIJA SUSPENZIJA S PRODULJENIM OSLOBAĐANJEM
PHYSICAL-CHEMICAL CHARACTERIZATION OF SUSPENSION WITH PROLONGED RELEASE

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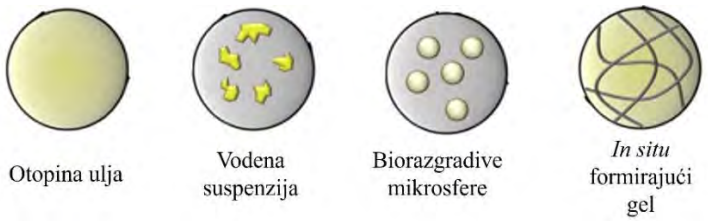
Farmaceutski proizvodi s produljenim oslobađanjem namijenjeni su za tjednu, mjesečnu ili višemjesečnu primjenu, formulirani tako da omogućuju kontrolirano otpuštanje djelatne tvari. Pacijentima pružaju stalnu terapijsku koncentraciju lijeka, a time i efektivnije liječenje. Na slici su prikazane četiri klase farmaceutskih proizvoda s produljenim oslobađanjem.
Jedna od najučestalijih formulacija u području razvoja farmaceutskih sustava s produljenim oslobađanjem je vodena suspenzija na čija fizikalno-kemijska svojstva će se ovaj rad fokusirati. Tijekom razvoja takvih sustava jedno od ključnih svojstava koje treba razmotriti je dugoročna stabilnost formulacije na koju utječe nepovoljna termodinamika suspenzija. Budući da veličina čestica određuje sigurnost primjene i učinkovitost suspenzija neki od izazova u fizikalnoj stabilnosti su sljedeći procesi: aglomeracija, sedimentacija, Ostwaldovo zrenje i sekundarna nukleacija [1,2].
Manje čestice kompenziraju proces sedimentacije putem Brownovog gibanja pa se smanjenje veličine čestica najčešće koristi za sprječavanje značajnijeg taloženja čestica. Na aglomeraciju čestica utječu površinska napetost, struktura površinski aktivnih tvari i zeta potencijal, dok na brzinu difuzije lijeka s površine čestica utječe viskoznost sredstva za suspenziju. Stoga najstabilnije suspenzije imaju prilično nisku topljivost u vodi i suspendirane su u sredstvu koje sadrži aditive koji povećavaju viskoznost [1,2]. U ovom radu prikazana je fizikalno-kemijska karakterizacija vodene suspenzije sa produljenim oslobađanjem pomoću reoloških mjerenja i mjerenja brzine sedimentacije.

Ključne riječi: suspenzija, produljeno oslobađanje, viskoznost, brzina sedimentacije

[1] R. Holm, R.W. Lee, J. Glassco et al, *AAPS J.* 25 (2023) 49.
[2] J. E. Kipp, *Int. J. Pharm* 284 (2004) 109-112.



CYTOPROTECTION OF FERROCENE-CONTAINING CURCUMIN ANALOGUE IN HUMAN KERATINOCYTES

Marina Miletić, Teuta Murati, Veronika Kovač, Lidija Barišić, Ivana Kmetič
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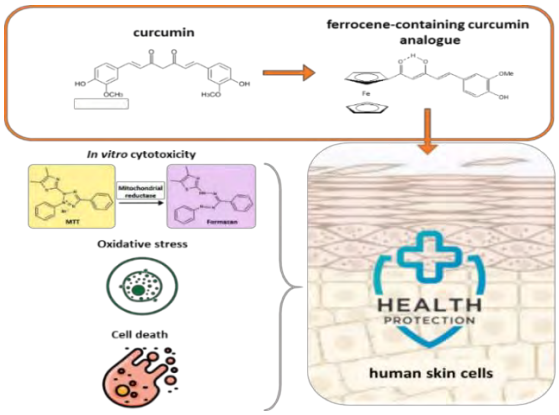
Potential skin protective effects are attributed to polyphenols due to their antioxidant, anti-inflammatory and antiaging properties. Herein, we have selected curcumin (CRC) to investigate mechanisms involved in human keratinocytes protection. In addition, we tried to overcome the limitations of CRC application due to poor pharmacokinetics by introducing ferrocene into CRC structure. In novel (previously synthesized) ferrocene-containing curcumin analogue (FCA) one benzylidene group of CRC is replaced by ferrocene. CRC and FCA were tested in range 2.5 - 50 μM and cell viability was monitored by MTT assay, while intracellular effects were assessed by cytofluorimetric analysis. Strong growth inhibition in HaCaT cells after 48h of CRC exposure was confirmed with MTT method with significant effects in concentrations ≥ 2.5 μM. Keratinocyte's survival at doses ≥ 20 μM was less than 15%. Opposite to CRC-treated cells, cell culture treated with FCA showed an apparently higher viability and proliferation rate. Cytofluorimetric analysis confirmed notably elevated apoptotic cell fraction (late apoptotic/dead cells -73.88%) after treatment with 50 μM CRC, while FCA did not affect cell viability (level of apoptotic and necrotic cell death was low - 5.19%). ROS induced by *tert*-butyl hydroperoxide were effectively supressed by both, CRC and FCA. Our findings suggest that FCA has an important role in protection of skin cells against ROS-related pathological processes and associative cell death induction.

Keywords: cell death, cell viability, curcumin, ferrocene derivatives, ROS



EFFECT OF CURCUMIN AND NUTRIENT DEPRIVATION ON BREAST CANCER CELL VIABILITY AND PROLIFERATION

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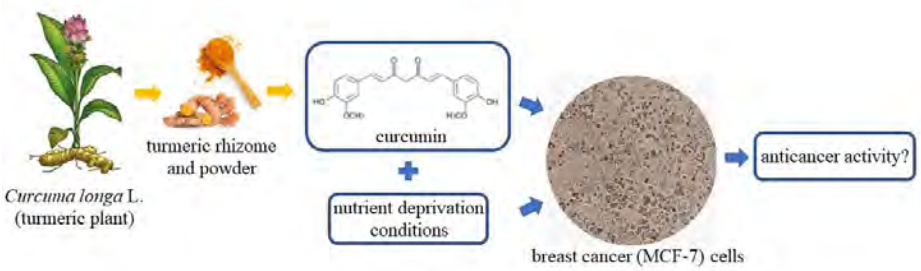
Nutritional interventions often aim to enhance cancer treatment therapies. Extensive research over the last decades suggests potential role of polyphenol curcumin (derived from the rhizome of *Curcuma longa* L.) in modulating cancer development and progression. The aim of this study was to determine whether nutritional deprivation combined with curcumin application can suppress cancer cell viability and proliferation. Breast cancer (MCF-7) cells were cultured in different media (commercially available DMEM media with high (4500 mg/L) or low (1000 mg/L) glucose concentration, and these media diluted with PBS or HBSS in ratios 1:1 and 2:1). DMEM (high or low glucose) diluted with 1/3 PBS significantly inhibited MCF-7 proliferation (determined by MTT method), while the viability was still sufficient to set up experiments of nutrient deprivation combined with curcumin. Curcumin (2.5 - 100 μM) additionally enhanced the effect of nutrient deprivation in a dose-dependent manner. When cells were grown in PBS-diluted media (either high or low glucose), curcumin at doses ≥ 50 μM caused a strong growth inhibition (75% compared to control). In addition, the proportion of apoptotic cells in the culture apparently increased with increasing curcumin concentration. Dilution of all nutrients with PBS had a pronounced effect on reducing cancer cell growth, in contrast to the amount of glucose in the medium, which did not appear to be a limiting parameter for cell viability.

Keywords: curcumin, cancer, nutrient deprivation, cell viability, flow citometry



INHIBICIJSKO DJELOVANJE 1,2,3-TRIAZOLNIH SOLI NA KOLINESTERAZE

INHIBITORY ACTIVITY OF 1,2,3-TRIAZOLIUM SALTS AGAINST CHOLINESTERASES

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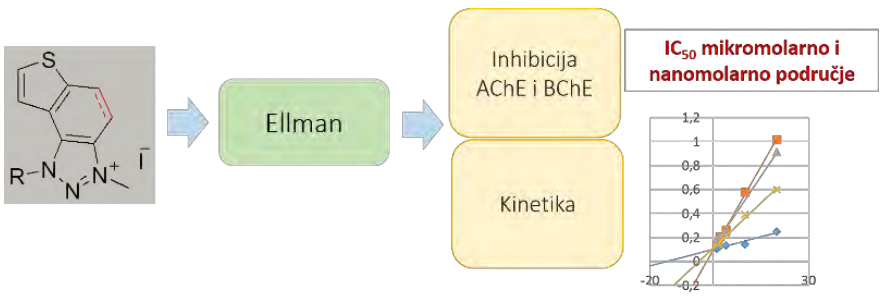
Enzimi kolinesteraze, prije svega acetilkolinesteraza (AChE) te u nekoj mjeri i butirilkolinesteraza (BChE), čine trenutno ciljane mete u tretmanu Alzheimerove bolesti. U dizajnu novih struktura, koje djeluju kao inhibitori enzima AChE i BChE, zanimljiv osnovni kostur predstavlja 1,2,3-triazol koji je sastavni dio u strukturama raznih lijekova. U ovom radu prikazani su rezultati inhibicijskih svojstava serije 1,2,3-triazolnih soli na enzime AChE i BChE. Svi ispitani derivati su pokazali značajnu inhibicijsku aktivnost prema oba enzima, naročito prema BChE za čiju su inhibiciju pojedini spojevi postigli IC_{50} vrijednost u nanomolarnom području [1]. Ključne odrednice u analizi odnosa strukture i aktivnosti bili su vrsta supstituenta na triazolnom prstenu, aromatičnost prstenastog sustava i usporedba s analozima bez naboja. Osim inhibicijske aktivnosti, provedeno je i ispitivanje enzimatske kinetike s odabranim derivatima. Tip inhibicije procijenjen je iz Lineweaver-Burk dijagrama.

Ključne riječi: inhibicija kolinestraza, AChE, BChE, triazolne soli

[1] M. Mlakić, D. Barić, A. Ratković, I. Šagud, I. Čipor, I. Piantanida, I. Odak, I. Škorić, *Molecules* 29 (2024) 1622.



SYNTHESIS AND ANTIBACTERIAL ACTIVITY OF NOVEL 1,2,3-TRIAZOLE DERIVATIVES OF BENZOXAZOLE

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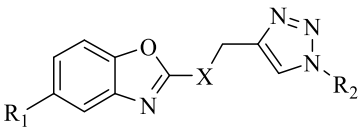
Recently, the overuse of antibiotics in humans, animals, and agriculture has led to a growing number of bacterial strains developing resistance to commercial antibiotics. Consequently, a significant number of deaths are occurring worldwide, and clinicians are facing a shortage of effective treatments. Because of that there is an increased demand to develop new, potent antibacterial agents. Benzoxazoles are structural isosteres of natural nucleotides and represent an important class of heterocyclic compounds exhibiting exceptional biological activities such as anticancer, antibacterial, anti-inflammatory and antiviral [1,2].

In order to evaluate their i*n vitro* antibacterial activity against Gram-positive and Gram-negative bacteria, novel derivatives of benzoxazole containing 1,2,3-triazole ring as a pharmacophore were prepared. Propargylated 2-aminobenzoxazoles and 2-thiobenzoxazoles were synthesized in a two-step reaction including cyclization reaction of 2-aminophenol using di(imidazole-1-yl)methanimine or carbon disulfide, and subsequent alkylation reaction with propargyl bromide. 2-amino- and 2-thiobenzoxazole derivatives with 1,2,3-triazole moiety were synthesized by Cu(I) catalyzed click reaction of 2-propargylated benzoxazole derivatives with corresponding azides. The structures of synthesized benzoxazole derivatives were confirmed by ^{1}H and ^{13}C NMR spectroscopy and mass spectrometry as well.

Keywords: benzoxazole, 1,2,3-triazole, click reaction, antibacterial activity

[1] C. P. Kaushik, M. Chahal, *J. Chem. Sci.* 132 (2020) 142.
[2] A. Parate, L. K. Soni, R. Malviya, *Der Pharmacia Sinica* 4 (2013) 130.



R_1: H, Me, OMe, Cl, F
R_2: alkyl, aryl, coumarin
X: NH, S

MASS SPECTROMETRY IMAGING DISCERNS THE METABOLOME OF CD19+ LYMPHOCYTES IN UNTREATED AND TREATED SUBJECTS WITH CHRONIC LYMPHOCYTIC LEUKEMIA

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Chronic lymphocytic leukemia (CLL) is a monoclonal lymphoproliferative disease characterised by increased production of dysfunctional CD19+ B-lymphocytes and heterogenus clinical sympthoms between patients. Bcl-2 inhibitors, the most common of wich is venetoclax, are used in CLL treatment. A single-cell MSI method for CD19+ B-lymphocyte metabolic profiling has previously been developed [1]. The aim of this study was to analyse and compare the metabolome of CD19+ lymphocytes (n=15 per mass range) from a CLL subject on venetoclax therapy to a CLL subject who did not receive therapy. Principal component analysis (PCA) was used for dimensionality reduction and for visualisation of the cell groups separation. P<0,05 and 2-fold change signal intensities between cell groups were considered significant. There were statistically significant differences in expression of m/z signals among groups of cells, and these m/z signals were tentatively identified.

Keywords: mass spectrometry, Venetoclax, metabolomics, B-Lymphocyte

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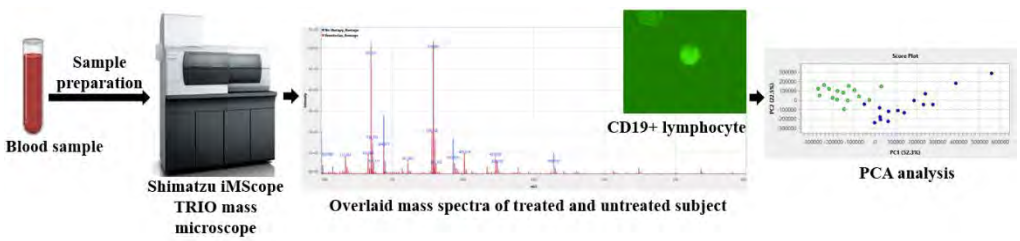

ANTIPROLIFERATIVE ACTIVITY OF QUINOLINE- AND COUMARIN-BASED LIGANDS WITH RHENIUM(I) TRICARBONYL COMPLEXES

Martina Piškor[1], Ivan Ćorić[2], Berislav Perić[3], Katarina Mišković Špoljarić[2], Srećko I. Kirin[3], Ljubica Glavaš-Obrovac[2], Silvana Raić-Malić[1]

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Quinoline and coumarin derivatives, found in many biologically active compounds, exhibit notable anticancer activity [1,2]. In our previous studies, coumarin-triazole hybrid was found to have a pronounced inhibitory effect against HeLa cell lines with IC_{50} = 0.9 μm, while quinolone-ferrocene conjugate exhibited activity against K562 (IC_{50} = 7.9 μM) [1,2]. Furthermore, our results showed that coordination of coumarin ligands with Re(I) significantly enhanced antiproliferative activity [3]. Herein, we present the synthesis, spectroscopic characterization and biological evaluations of coumarin- and quinoline-based ligands with rhenium(I) tricarbonyl complexes.

Keywords: quinoline, coumarin, rhenium(I) tricarbonyl complexes, antiproliferative activity

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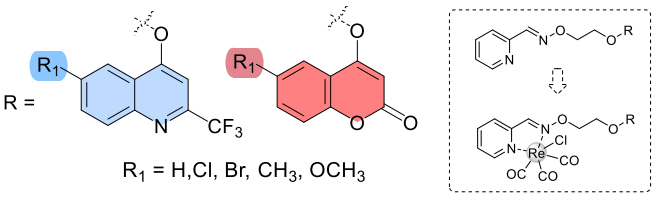

UTJECAJ HIDROKSIETIL CELULOZE NA VISKOZNOST GOTOVOG LIJEKA (KAPI ZA OKO)
IMPACT OF HYDROXYETHYL CELLULOSE ON VISCOSITY OF FINAL DRUG PRODUCT (EYE DROPS)

Ivana Poropat, Karla Dubaić, Maria Jurčević, Dijana Jureša, Lela Munjas Jurkić, Leo Štefan, Tea Tomljanović

Istraživanje i razvoj, Jadran – Galenski laboratorij d.d., Svilno 20, 51000 Rijeka

Hidroksietil celuloza (HEC) je polimer široke primjene u farmaceutskoj industriji [1]. Ovisno o duljini lanaca, odnosno molekulskoj masi HEC-a mijenja se i viskoznost samog polimera, ali i otopine lijeka u kojem se HEC koristi kao sredstvo za povećanje viskoznosti [2]. Cilj ovog istraživanja bio je razvoj generičkog lijeka (kapi za oko) s HEC-om, uz određivanje kritičnih atributa sirovine i procesa izrade koji utječu na viskoznost, koja je kod kapi za oko kritični parametar. Viskoznost ispitivanog gotovog lijeka ovisi o viskoznosti otopine HEC-a nakon sterilizacije. Ispitan je utjecaj tipa i koncentracije HEC-a na reološke karakteristike otopine. Također, ispitan je utjecaj vremena otapanja, tipa korištenog mješala te kombinacija temperature i vremena zagrijavanja na viskoznost otopine HEC-a. Tip i koncentracija HEC-a određeni su kombinacijom reoloških i kromatografskih tehnika. Utvrđeno je da čak i male promjene (do 5 %) u koncentraciji HEC-a nose značajan utjecaj na viskoznost otopine HEC-a (do 10 %). Od procesnih parametara, vrijeme provedeno na temperaturama iznad 70 °C najviše utječe na pad viskoznosti otopine HEC-a. Zaključno, osim odabira odgovarajućeg tipa HEC-a i njegove koncentracije, odabir procesnih parametara u procesu izrade same otopine ključni su za dobivanje gotovog lijeka zadovoljavajuće kvalitete i sigurne primjene za pacijenta.

Ključne riječi: hidroksietil celuloza (HEC), viskoznost, kapi za oko

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SYNTHESIS AND ANTIBACTERIAL ACTIVITY OF NOVEL 1,2,3-TRIAZOLYL BENZIMIDAZOLE–BENZOXAZOLE HYBRIDS

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Benzoxazoles and benzimidazoles are prominent in medicinal chemistry due to their wide spectrum of pharmacological activities such as antibacterial, antifungal, anticancer, anti-inflammatory, antiparkinson, inhibition of hepatitis C virus, ect. [1,2]. Molecular hybridization is a powerful approach in drug design that involves combining the benefits of different molecules to create a novel compound with improved pharmacological properties, such as increased potency and specificity [3]. This work describes a synthesis of benzoxazole-benzimidazole hybrids, designed to leverage the synergistic benefits of both parent compounds. A triazole ring has been incorporated as a novel pharmacophore, introducing diversity to the molecular structure. Benzoxazole-benzimidazole hybrids were prepared by condensation reaction of benzoxazole-2-thiol and 2-(chloromethyl)benzimidazole. The propargylation reaction of the hybrids with propargyl bromide yielded *N*-propargylated benzimidazole-benzoxazole hybrids, which were subsequently converted into 1,2,3-triazole derivatives through a copper-catalyzed click reaction with the corresponding azides.

Keywords: benzoxazoles, benzimidazoles, 1,2,3-triazole, hybrids, click reaction

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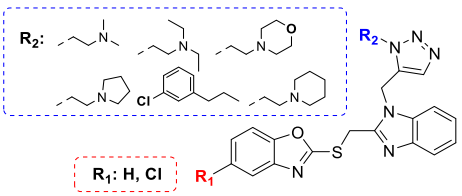

SYNTHESIS AND ANTIPROLIFERATIVE ACTIVITY OF NEW HYDRAZONE-BRIDGED BENZOTHIAZOLE DERIVATIVES

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Benzothiazole is considered a privileged structure in medicinal chemistry due to its various biological activities such as antimicrobial, antitumor, antituberculostatic, and antimalarial effects. Therefore, this heterocyclic core is often found in drugs available on the market that are used to treat various diseases [1]. Furthermore, the hydrazone moiety has found application in drug delivery to tumor cells due to faster hydrolysis of the imine bond in acidic pH compared to physiological conditions [2].

This work describes the *solvent free* mechanochemical synthesis and *in vitro* antiproliferative activity of targeted hydrazone-bridged benzothiazole derivatives. 2-hydrazinylbenzothiazoles were prepared by the reaction of 2-amino-6-substituted derivatives of benzothiazole with hydrazine hydrate, while 4-alkoxybenzaldehydes were prepared by *O*-alkylation reaction of 4-hydroxybenzaldehyde with corresponding aminoalkyl halides. Hydrazone-bridged benzothiazole derivative substituted with chlorine at the C-6 position of benzothiazole and with fluorine at the *meta*-position and *N*,*N*-dimethyl substituent at the *para*-position of the benzene ring showed the most pronounced antiproliferative activities against pancreatic adenocarcinoma cells (CAPAN-1, IC_{50} = 0.6 μM) and non-small lung cancer cells (NCI-H460, IC_{50} = 0.9 μM).

Keywords: benzothiazole, hydrazone, antiproliferative activity, mechanochemistry

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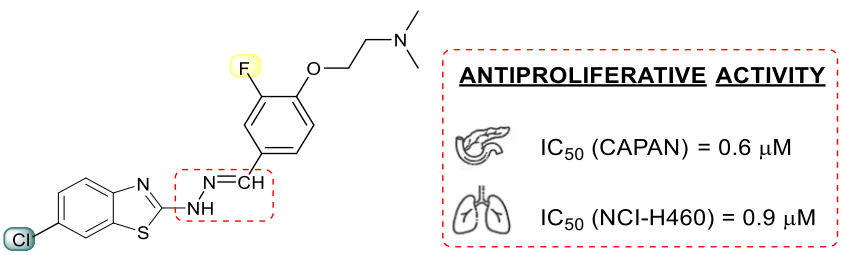

PRIMJENA AQbD PRINCIPA U RAZVOJU METODE ZA ZA SRODNE SUPSTANCIJE LOTEPREDNOL ETABONATA U GOTOVOM PROIZVODU

APPLYING AQbD APPROACH IN DEVELOPMENT OF METHOD FOR RELATED SUBSTANCES OF LOTEPREDNOL ETABONATE IN DRUG PRODUCT

Ivan Sušanj, Petra Cukrov, Daria Juretić Perišić, Anja Kovač Lesić
Jadran – galenski laboratorij d.d., Svilno 20, 51000 Rijeka

Loteprednol etabonat (LE) retrometabolički je dizajniran kortikosteroid za lokalnu, topikalnu primjenu koji se koristi u liječenju umjerene do teške bolesti suhog oka (eng. *Dry eye disease*, *DED*) [1]. Tijekom razvoja JGL proizvoda kao suspenzije u formi kapi za oko razvijena je metoda tekućinske kromatografije za određivanje srodnih supstancija LE koristeći principe kvalitete ugrađene kroz dizajn u analitici (eng. *Analytical Quality by design*, *AQbD*). Dizajn eksperimenta, obrada podataka i kreiranje operativnog prostora metode provedeni su u programu Fusion QbD®. U razvoj metode je uključen LE i 7 srodnih supstancija, a varirani parametri su vrsta stacionarne i mobilne faze, protok i gradijent protoka mobilne faze te temperatura grijača kolone. Nakon provedenih eksperimenata definirana je metoda i operativni prostor metode (eng. *Method operable design region*, *MODR*), uz odabranu stacionarnu fazu i tip mobilne faze.

Ključne riječi: loteprednol etabonat, srodne supstancije, LC, Fusion®, AqbD

[1] K. Beckman, J. Katz, P. Majmudar, A. Rostov, *J. Ocul. Pharmacol. Ther.* 36 (7) (2020) 497-511.

Prostor znanja razvijene metode.

ANALIZA AZALIDA PRIMJENOM BIOFARMACEUTSKOG KLASIFIKACIJSKOG SUSTAVA
ANALYSIS OF AZALIDES BY USING BIOPHARMACEUTICS CLASSIFICATION SYSTEM

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Azalidni antibiotici (n = 310), uključujući azitromicin (AZM) i njegove prekursore [1], analizirani su pomoću biofarmaceutskog klasifikacijskog sustava (*Biopharmaceutics Classification System*, BCS) ADMET Predictor® na temelju njihovih efektivnih permeabilnosti (S+P_{eff}, cm/s 10^{-4}) predviđenih *in silico* te intrinzičkih topljivosti u vodi (S+$S_{intrins}$, mg/ml), za doze od 5, 50 i 500 mg, s ciljem otkrića učinkovitog azalida veće oralne bioraspoloživosti od azitromicina (37 %). Sustav BCS razlikuje četiri klase: I. spojevi velike topljivosti i velike permeabilnosti koji se vrlo dobro apsorbiraju, II. spojevi slabe topljivosti i velike permeabilnosti čija je apsorpcija ograničena brzinom otapanja, III. spojevi velike topljivosti i slabe permeabilnosti čija je apsorpcija ograničena permeabilnošću i IV. spojevi slabe topljivosti i slabe permeabilnosti čija je oralna bioraspoloživost vrlo mala [2]. Rezultati analize BCS ukazuju da su analizirani azalidi pretežito klasificirani u klasama III. i IV., zavisno o dozi: u dozi od 5 mg 91,61 % azalida nalazi se u klasi III., a tek 7.09 % u klasi IV., u dozi od 50 mg se 69,03 % azalida nalazi u klasi III., a 29,68 % u klasi IV., dok je u dozi od 500 mg 8,71 % azalida u klasi III., 90,00 % u klasi IV., a manje od 1 % ispitivanih azalida u klasama I. i II. Stoga optimiranje bioraspoloživosti predstavlja velik izazov u daljnjim istraživanjima ove klase antibiotika.

Ključne riječi: azalidi, azitromicin, *in silico*, oralna bioraspoloživost, BCS

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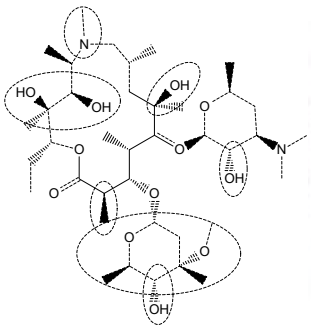
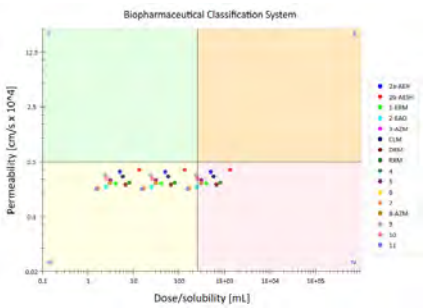
[2] G. L. Amidon, H. Lennernäs, V. P. Shah, J. R. Crison, *Pharm. Res.* 12 (1995) 413.





ANALIZA AZALIDA *IN SILICO* PRIMJENOM PROŠIRENOG SUSTAVA ZA KLASIFIKACIJU KLIRENSA

IN SILICO ANALYSIS OF AZALIDES BY USING EXTENDED CLEARANCE CLASSIFICATION SYSTEM

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Predviđanje mehanizama klirensa novih kemijskih entiteta omogućuje brži napredak u otkriću lijekova te olakšava procjenu rizika farmakokinetičke varijabilnosti povezane s interakcijama lijekova i farmakogenomikom [1]. Pomoću Proširenog sustava za klasifikaciju klirensa (*Extended Clearance Classification System*, ECCS) ADMET Predictor® koji se koristi za predviđanje prevladavajućeg mehanizma klirensa lijekova (K, mL/min) na temelju ionizacije, molekulske mase i stanične permeabilnosti, analizirani su azalidni antibiotici (n = 310), uključujući azitromicin (AZM) i njegove prekursore [2]. Sustav ECCS razlikuje šest klasa na temelju primarnog mehanizma klirensa: 1A. mehanizam metabolizma (kiseline/zwitterioni velike permeabilnosti s $M \leq 400$ Da), 1B. mehanizam unosa u jetru posredovan transporterom (kiseline/zwitterioni velike permeabilnosti s $M > 400$ Da), 2. mehanizam metabolizma (baze/neutralni spojevi velike permeabilnosti), 3A. bubrežni mehanizam (kiseline male permeabilnosti/zwitterioni s $M \leq 400$ Da), 3B. mehanizam unosa u jetru posredovan transporterom ili bubrežni (kiseline slabe permeabilnosti/zwitterioni s $M > 400$ Da) i 4. bubrežni mehanizam (baze/neutralni spojevi slabe permeabilnosti).
Prema dobivenim rezultatima analize ECCS, 80,00 % analiziranih azalida nalazi se u Klasi 4. kao i azitromicin, 19,03 % u Klasi 3.B, te 0,73 % u Klasi 2. što ukazuje na njihovu slabu biotransformaciju i izlučivanje u nepromijenjenom obliku uglavnom urinom.

Ključne riječi: azalidi, azitromicin, *in silico*, klirens, ECCS

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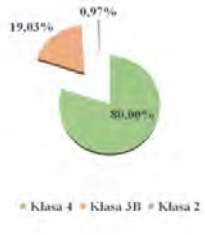

DEVELOPMENT AND VALIDATION OF UHPLC-MS/MS METHOD FOR SIMULTANEOUS QUANTIFICATION OF ASCORBIC AND DEHYDROASCORBIC ACIDS

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Ascorbic acid (AA) is the active form of vitamin C present in food and commonly used as a dietary supplement. Under oxidative conditions, AA is readily converted to dehydroascorbic acid (DHAA) which also possesses biological activity [1]. When analysing vitamin C content, it is important to consider both AA and DHAA. The liquid chromatography method was optimized by using different mobile phases, organic modifiers and flow rates (0.1% acetic acid in water and 0.7 mL/min flow rate were selected). Separation was achieved on C18 stationary phase and 20 °C was selected as the optimum column temperature. A triple quadrupole mass spectrometer with electrospray ionization was employed in negative mode. The developed method is based on MRM transitions at their optimum collision energies (quantifier and one qualifier for each compound). The main problem in the AA analysis is related to its instability. The method was validated for quantification in the range of 10-50 µg/mL according to the ICH guidelines (linearity, limits of detection and quantification, specificity, accuracy, precision and robustness). The presented procedure was successfully applied in the analysis of supplements with a declared amount of vitamin C.

Keywords: vitamin C, ascorbic acid, dehydroascorbic acid, UHPLC-MS/MS, validation

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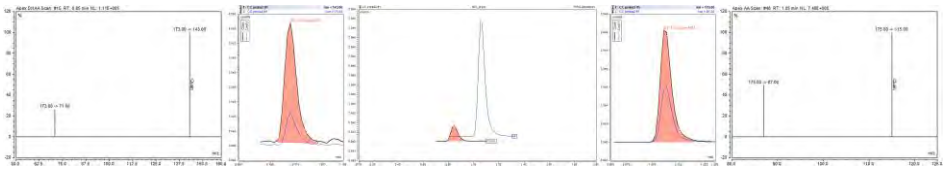

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KEMIJA U POLJOPRIVREDI I ŠUMARSTVU

CHEMISTRY IN AGRICULTURE AND FORESTRY

THE EFFECT OF SELENIUM ON THE PHOTOSYNTHETIC EFFICIENCY OF KALE MICROGREENS

Doria Ban[1], Anja Melnjak[2], Martina Šrajer Gajdošik[1], Ivna Štolfa Čamagajevac[2], Lidija Kalinić[2], Selma Mlinarić[2]

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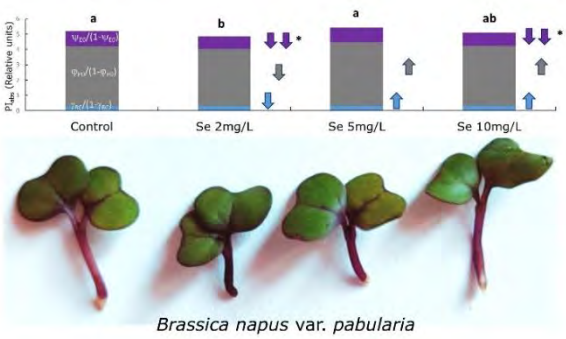
Biofortification with selenium (Se) is a promising solution for the rapid cultivation of fresh microgreens rich in microelements to meet the recommended daily intake. Hydroponically grown microgreens of kale (*Brassica napus* var. *pabularia*) were treated with three Se concentrations (2, 5 and 10 mg/L) for five days, after which photosynthetic efficiency was determined by measuring the chlorophyll *a* fluorescence. The results showed a significantly lower value of the performance index (PI_{abs}) at 2 mg/L of Se compared to the control. The decrease in PI_{abs} occurred due to a significant decrease in electron transport after the primary electron acceptor ($\psi_{E0}/(1-\psi_{E0})$) while there was no significant effect on the change in the size of antennas and/or the density of reaction centers ($\gamma_{RC}/(1-\gamma_{RC})$) nor primary photochemistry ($\varphi_{P0}/(1-\varphi_{P0})$). Other used concentrations (5 and 10 mg/L) did not significantly affect the PI_{abs} compared to control, indicating that kale microgreens tolerate those concentrations of Se better than 2 mg/L. Such results suggest that 5 and 10 mg/L of Se could potentially be used for biofortification of kale microgreens.

Keywords: Brassica napus var. *pabularia,* performance index, biofortification



Brassica napus var. *pabularia*

HOLOGRAM QSAR MODEL FOR THE ANTIFUNGAL ACTIVITY OF COUMARIN-1,2,4-TRIAZOLES

Maja Karnaš, Vesna Rastija, Domagoj Šubarić, Dejan Agić
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The hologram quantitative structure-activity relationship (HQSAR) is a two-dimensional (2D)-QSAR method that uses substructural fragments in a molecule as descriptors relevant to its biological activity. Generated molecular holograms encode all possible fragments within a determined radius, including branched, cyclic, and overlapping fragments. Therefore, HQSAR enables the identification of the most significant fragment or atom contribution in explaining the variation in activity [1]. This study employed the HQSAR to elucidate the important structural features of the observed antifungal activity of coumarin-1,2,4-triazoles against the phytopathogen *Sclerotinia sclerotiorum* [2]. The models were generated by ChemMaster Basic 1.2 software on a set of 28 compounds (training set) using circular fragment selection within the topological radius of 4, including bond order and chirality. The logarithmic values of mycelial growth inhibition percentage were used as the response variable. The best obtained model satisfied the criteria of the internal validation (R^2 = 0.73), the cross-validation (R^2_{CV} = 0.60), and external validation (R^2_{Ext} = 0.76) performed on the test set comprised of six compounds. The analysis indicated that the coumarin moiety contributed more to the increased activity than the triazole part. However, the triazole moiety had a more prominent role when linked to C-7 of the coumarin core. Additionally, the absence of a methyl group at C-4 of coumarin significantly reduced its contribution to the antifungal activity.

Keywords: coumarin-1,2,4-triazoles, antifungal activity, hologram QSAR

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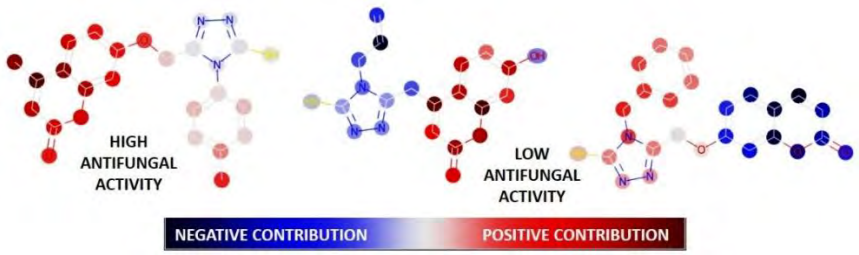

ANALIZA STRUKTURE I SVOJSTAVA DELIGNIFICIRANIH DRVNIH VLAKANA ČETINJAČA I LISTAČA

ANALYSIS OF THE STRUCTURE AND PROPERTIES OF DELIGNIFIED WOOD FIBERS OF SOME HARDWOODS AND SOFTWOODS

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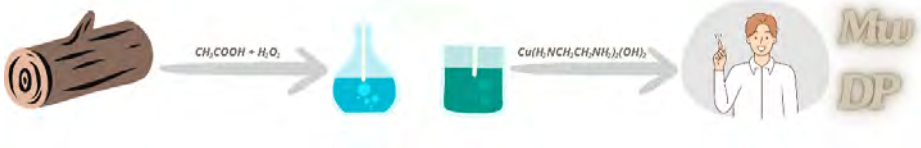
Današnja proizvodnja papira visoke čvrstoće, visoke bjeline i dobrih uporabnih svojstava neminovno podrazumijeva kombiniranje celuloznih vlakana različitih dimenzija i oblika. U pravilu se kombiniraju kraća i duža vlakna, dok su sva ostala svojstva papira određena dodacima i procesom proizvodnje. Osim dimenzija samih vlakana, važni pokazatelji kvalitete i prikladnosti vlakana pojedine vrste drva za proizvodnju papira su stupanj polimerizacije (DP) celuloze i njezina molekulska masa (M_w). U ovom radu su delignificirani uzorci 10 vrsta drva te su određena prethodno navedena svojstva, uz određivanje bakrovog (Cu) broja. Rezultati ispitivanja su pokazali da su vrijednosti DP i M_w celuloze, pripremljene od ispitivanih vrsta, prilično visoke, te da vlakna hrasta (*Quercus robur* L.) prema gotovo svim ispitivanim kriterijima ne zaostaju mnogo za vlaknima ostalih, komercijalno češće korištenih vrsta četinjača.

Ključne riječi: celuloza, četinjače, delignifikacija, molekulska masa, listače



ZAŠTITA OKOLIŠA
ENVIRONMENTAL PROTECTION

EFFICIENCY OF SUPERCRITICAL CO_2 IN EXTRACTION OF PHA FROM SECOND-GENERATION WASTE BIOMASS

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Polyhydroxyalkanoates (PHA) are biodegradable biopolymers, a valuable alternative to fossil-based polyesters. Industrially, they are produced from pure microbial cultures using enzymatically derived sugars. A more sustainable option is the use of waste biomass and mixed microbial cultures. Common fermentation processes for obtaining PHA are submerged fermentation (SMF) and solid-state fermentation (SSF). Key steps are extraction and purification, which include solubilizing intracellular PHA, separating biomass, and isolating it from the solvent. The most common methods are solvent extraction, flotation, digestion, two-phase aqueous extraction, and supercritical fluid extraction. In this study, PHA extraction from waste biomass (potato starch and chickpeas waste), was carried out using innovative technique. Supercritical fluid extraction using CO_2 as solvent was performed under following conditions: pressure 300 bar, temperature 40 °C, solvent flow rate 1.4 kg/h and time 60 min. Achieved yield of total extract from this extraction parameters was 2.49% m/m. The total extract is subjected to purification by physico-chemical procedures in order to extract pure PHA.

Keywords: PHA, waste, supercritical CO_2 extraction

This research was conducted as part of the project „*Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products*" (NPOO.C3.2.R3-I1 .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).

TPS/PHBV BIOMATERIJALI ZA ODRŽIVO PAKIRANJE HRANE

BIOBASED TPS/PHBV BLENDS FOR SUSTAINABLE FOOD PACKAGING

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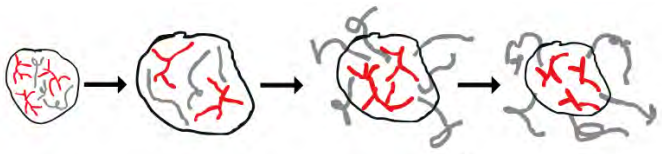
Polihidroksialkanoati (PHA), a posebno poli(3-hidroksibutirat-ko-3-hidroksivalerat) (PHBV), istaknuli su se kao obećavajući kandidati za zamjenu tradicionalne plastike iz fosilnih goriva. PHBV je biorazgradljivi polimer s dobrim mehaničkim svojstvima i velikim potencijalom, no visoka tržišna cijena ograničava njegovu širu primjenu.

Ovaj rad istražuje pripremu biomaterijala na bazi PHBV-a i termoplastičnog škroba (TPS), proizvedenog metodom lijevanja uz glicerol kao plastifikator. Mješavine TPS-a i PHBV-a pripremljene su u Brabender gnjetilici, a analizirana su njihova toplinska, morfološka, mehanička i barijerna svojstva. Diferencijalna pretražna kalorimetrija (DSC) analiza ukazuje na djelomičnu mješljivost TPS/PHBV mješavina, što je potvrđeno i morfološkom analizom pretražnim elektronskim mikroskopom (SEM). Termogravimetrijska analiza (TGA) pokazuje dvostupanjsku razgradnju. PHBV djeluje kao ojačavajuća komponenta koja poboljšava mehanička svojstva TPS-a, čineći mješavinu otpornijom na lom. Dodatak PHBV-a TPS-u dolazi do smanjenja vrijednost propusnosti vodene pare.

Rezultati sugeriraju da TPS/PHBV mješavine mogu biti održiva alternativa sintetskim polimerima u industriji pakiranja hrane, kombinirajući biorazgradivost i poboljšana svojstva uz smanjenje troškova.

Ključne riječi: poli(3-hidroksibutirat-ko-3-hidroksivalerat) (PHBV), termoplastični škrob, metoda lijevanja, pakiranje hrane

Ovo istraživanje provedeno je u sklopu projekta „*Proizvodnja i razvoj kompostabilne ambalaže iz otpadne biomase za pakiranje industrijski prerađenih prehrambenih proizvoda*" (NPOO.C3.2.R3-Il .04.0059) financiranog iz Nacionalnog plana oporavka i otpornosti (financiranog od strane Europske unije, NextGenerationEU).



ISOLATION AND IDENTIFICATION OF MICROORGANISMS FROM WASTE BIOMASS AND THEIR APPLICATION IN THE PRODUCTION OF POLYHYDROXYALKANOATES

Dora Bramberger[1], Martina Miloloža[1], Krešimir Stublić[2], Matija Cvetnić[1], Vesna Ocelić Bulatović[1], Šime Ukić[1], Tomislav Bolanča[1], Marinko Markić[1], Lidija Furač[1], Jasmina Ranilović[3], Dajana Kučić Grgić[1]

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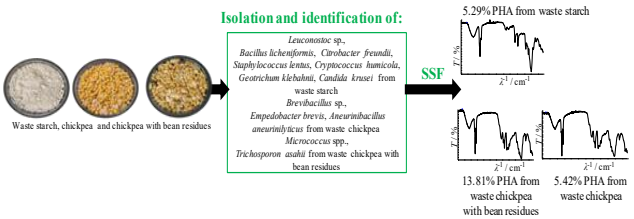
In this study, waste starch, waste chickpea, and waste chickpea with bean residues were used to isolate microorganisms capable of producing polyhydroxyalkanoates (PHA). *Leuconostoc* sp., *Bacillus licheniformis*, *Citrobacter freundii*, *Staphylococcus lentus*, *Cryptococcus humicola*, *Geotrichum klebahnii*, and *Candida krusei* from waste starch; *Brevibacillus* sp., *Empedobacter brevis*, and *Aneurinibacillus aneurinilyticus* were isolated from waste chickpea; and *Micrococcus* spp. and *Trichosporon asahii* from waste chickpea with bean residues. Solid-state fermentation (SSF) was performed with shredded substrates in Erlenmeyer flasks with 100 g of each substrate and 10 mL of previously prepared bacterial suspension ($3.5 \cdot 10^9$ cells/mL) for 7 days at room temperature. The initial values of pH and moisture content have been determined: 4.453 and 44.77 % for starch, 5.545 and 58.06 % for chickpea, 5.011 and 59.86 % for chickpea with bean residues, respectively. According to the results, the highest accumulation of PHA of 13.81% was obtained from chickpea waste with bean residues which was confirmed by FTIR-ATR spectroscopy.

Keywords: polyhydroxyalkanoates, food industry waste biomass, solid-state fermentation

This research was conducted as part of the project „*Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products*" (NPOO.C3.2.R3-I1 .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).



PODZEMNE VODE ODLAGALIŠTA NEOPASNOG OTPADA „GORIČICA“

GROUNDWATERS OF NON-HAZARDOUS WASTE DISPOSAL SITE „GORIČICA“

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U ovom radu određivani su fizikalno-kemijski parametri (razina podzemne vode, temperatura, električna vodljivost, koncentracija amonijaka, fosfata, sulfata, nitrata, klorida, kadmija, olova, žive i arsena) u podzemnim vodama odlagališta neopasnog otpada „Goričica“ (u blizini grada Siska, Hrvatska) u periodu od 2019. do 2023. Uzorkovanje je provedeno na tri lokacije (piezometar 1, 2 i 3). Dobiveni rezultati pokazali su nešto manje, ali „skokovito“ povećanje koncentracija amonijaka i fosfata u uzorcima podzemnih voda uzetih na piezometrima 1 i 3 i češće i značajnije povećanje navedenih iona u uzorcima podzemnih voda uzetih na piezometru 2. Pretpostavlja se da do odstupanja od maksimalno dopuštene koncentracije NH_4^+ i PO_4^{3-} u podzemnim vodama u blizini lokacije piezometara 1 i 3 dolazi zbog primjene gnojiva na obradivim površinama kojima je okruženo odlagalište. Zbog odlaganja veće količine biootpada na malu plohu odlagališta te zbog doticaja oborinskih voda s otpadom, kao i izljevanja oborinskih voda iz oborinskih kanala, podzmene vode u blizini piezometra 2 pokazale su povećane koncentracije navedenih iona.

Ključne riječi: otpad, odlagalište, podzemne vode, amonijak, fosfati

ZAŠTO SMO UVELI AKREDITACIJU U ISTRAŽIVAČKI LABORATORIJ?
WHY DID WE INTRODUCE ACCREDITATION IN THE RESEARCH LABORATORY?

Irena Ciglenečki, Jelena Dautović, Zdeslav Zovko, Niki Simonović
Institut Ruđer Bošković, Odjel za istraživanje mora i okoliša,
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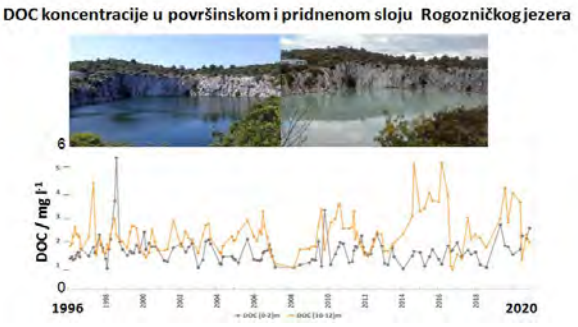
Laboratorij za fiziku mora i kemiju vodenih sustava (LFKVS), Zavoda za istraživanje mora i okoliša, Instituta Ruđer Bošković (IRB), punih 30 godina radi na karakterizaciji organske tvari u prirodnim vodama, uz poseban naglasak na određivanje totalnog, otopljenog i partikularnog organskog ugljika (TOC, DOC i POC) u prijelaznim i površinskim vodama, u moru. U zadnjih 30 godina sudjelovali smo u gotovo svim istraživačkim projektima vezanim za ispitivanje organske tvari u Jadranu, uključujući i monitoring programe. Uz područje sjevernog Jadrana, DOC se ispituje redovito u prijelaznim i priobalnim vodama Jadrana u okviru tzv. ekološkog monitoringa, zatim u Rogozničkom jezeru-Zmajevom oku kao jedinstvenom stratificiranom sustavu jadranske obale od 1994. g. Rezultati navedenih ispitivanja dio su jedne bogate baze podataka, a do sada su predstavljeni na brojnim domaćim i stranim skupovima, publicirani u nizu znanstvenih publikacija, kao i godišnjih skupnih izvještaja. S obzirom da na vjerodostojni i usporedivi rezultat pored kvalitetnog mjerenja, koje mora biti pouzdano, validirano i verificirano, utječe i složena logistička podrška koja prethodi samom postupku mjerenja u laboratoriju (pravilno uzorkovanje; filtracija svježih uzoraka na brodu; odgovarajuća oprema za čuvanje uzoraka do analize; prilagođavanje mjerenja TOC u uvjetima visokog saliniteta; interkalibracijska i interkomparacijska mjerenja i sl.), stečeno znanje i iskustvo, iskoristili smo za dobivanje akreditacije za metode određivanja orgnskog ugljika u prirodnim vodama (uključujući more) i sedimentu u skladu s normom HRN EN ISO/IEC 17025.Broj akreditacije 1577.

Ključne riječi: organski ugljik, prirodne vode, morski monitoring, akreditacija



THE IMPACT OF TREATED WASTEWATER ON MANGANESE CONCENTRATION IN BASIL PLANTS

Iva Ćurić[1], Luka Brezinščak[2], Fran Hrlić[1], Davor Dolar[1]

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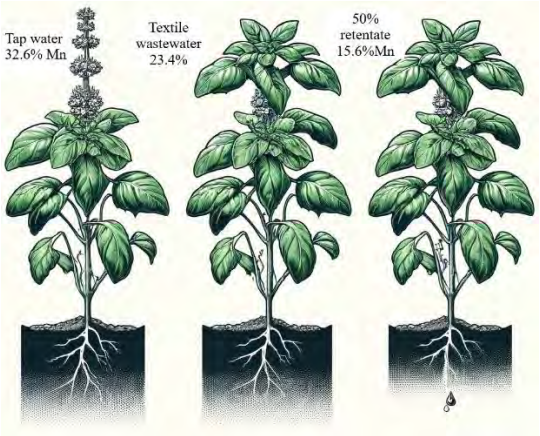
This study investigates the potential reuse of retentate from a hybrid membrane process involving ultrafiltration (UF) and reverse osmosis (RO) used in the treatment of textile wastewater (TWW). The reuse potential was evaluated by examining the concentration of manganese (Mn) in basil plants. High concentrations of Mn can lead to chlorosis and necrosis of the leaves, as well as reduced root growth and nutrient absorption. The plants were irrigated with three different types of water: raw TWW, 50% concentrated retentate, and tap water. The results showed that the Mn concentration in the plant material, based on dry weight, was 15.6% for plants irrigated with retentate, 23.4% for plants irrigated with TWW, and 32.6% for plants irrigated with drinking water. These findings suggest that the reuse of 50% concentrated retentate in this study could be successful in terms of Mn concentration. It was demonstrated that there is a higher Mn content in tap water compared to wastewater, which is very concerning. Nonetheless, the use of hybrid membrane processes can contribute to reducing Mn levels in both tap water and wastewater.

Keywords: manganese, ultrafiltration, reverse osmosis, textile wastewater, watering

This research was funded by the NATO Science for Peace and Security Programme under grant id. G6087.



PREGLED KEMIJSKIH METODA U ISTRAŽIVANJU GEOTERMALNIH LEŽIŠTA
AN OVERVIEW OF CHEMICAL METHODS IN GEOTHERMAL RESERVOIR EXPLORATION

Dragana Dogančić, Anita Ptiček Siročić
Sveučilište u Zagrebu Geotehnički fakultet, Hallerova aleja 7, 42000 Varaždin

Tijekom istraživanja geotermalnih resursa, bitnu ulogu ima i ispitivanje kemijskog sastava geotermalnih fluida. Upotreba različitih kemijskih metoda započinje tijekom prospekcije potencijalog ležišta, nastavlja se kroz sve faze pripreme za iskorištavanje i igra važnu ulogu ulogu tijekom cijelog korištenja geotermalnog resursa putem praćenja i upravljanja ležištem. Kemijski sastav vode rezultat je niza procesa, kao što su interakcija sa stijenama vodonosnika, miješanje s hladnom vodom iz plićih vodonosnika, itd. Određeni kemijski elementi mogu se koristiti i kao geotermometri te ukazivati na temperaturu vode u vodonosniku, a prisustvo određenih mineralnih vrsta u uzorcima bušotine može ukazivati na potencijalno hlađenje ili zagrijavanje geotermalnog sustava. Kemijski sastav i osobine vrućeg fluida bitne su i kod projektiranja bušotine kao i cjelokupnog sustava za iskorištavanje uskladištene topline, bilo da je riječ o grijanim staklenicima ili geotermalnoj elektrani. U konačnici, razumijevanje kemizma fluida bitno je i prilikom pronalaska najboljeg rješenja za iskorišteni geotermalni fluid čime se izravno pridonosi smanjenju utjecaja na okoliš.

Ključne riječi: geotermalna voda, kemijske metode, utjecaj na okoliš

ASSESSMENT OF THE TOXIC EFFECT OF MICROPLASTICS AND METALS BY THE ACUTE TOXICITY TEST (*Daphnia magna*)

Vlatka Filipović Marijić[1], Goran Filipović[2], Souban Said-Mahamoud[3], Marta Pinčić[2], Sara Šariri[1], Tatjana Mijošek[1]

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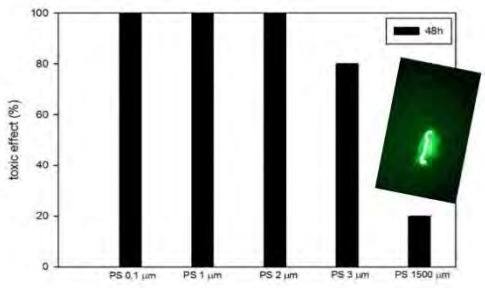
Microplastics (MPs) are particles smaller than 5 mm that, due to their small dimensions, easily reach all components of the environment, including organisms. Over the past decades, concerns about the potential of MPs as carriers of various pollutants have raised intention, because their interaction can have multiple harmful consequences for organisms. The aim of the present study was to determine the toxic effect of polystyrene (PS - 0.1-1500 μm; 0.1-100 mg l^{-1}), different metals (Ag, Al, Co, Cu, Pb, Zn – 50 μg l^{-1} and Cd - 25-1000 μg l^{-1}) and their combinations, by testing their influence on the survival rate of the water flea (*Daphnia magna* Straus, 1820). The results confirmed the dependence of the toxic effect of PS on its size and indicated the highest toxicity of 0.1-3 μm, as this is the size range available for ingestion in the water flea. Toxicity also increased with increasing concentration of PS and metals, while the combination of PS and Cd confirmed that plastics bind other pollutants, which affected toxicity and generally indicated a potential danger for aquatic organisms.

Keywords: microplastics, metals, toxicity, aquatic organisms



DEGRADATION OF NIRMATRELVIR IN WATER BY UV-C/H_2O_2 AND UV-C/$S_2O_8^{2-}$ PROCESSES

Lidija Furač, Lucija Švegović, Matija Cvetnić, Viktorija Martinjak, Kristina Bule Možar, Martina Miloloža, Marinko Markić, Dajana Kučić Grgić, Tomislav Bolanča, Šime Ukić

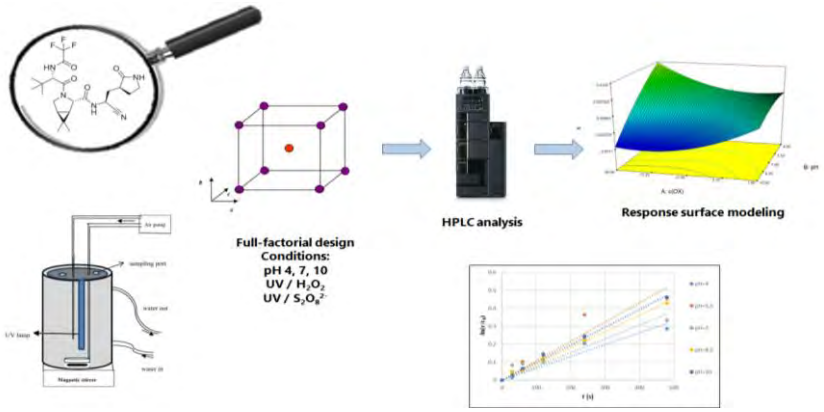
University of Zagreb Faculty of Chemical Engineering and Technology, Marulićev trg 19,10000 Zagreb

Antiviral substances aimed to treat severe acute respiratory syndrome coronavirus (SARS-CoV-2) are mostly new environmental pollutants whose occurrence in the environment is continuously increasing. They present a serious ecological and health risk that includes the safety of drinking water, antiviral resistance and destabilization of sensitive microbial communities. Unfortunately, there is very few information about their fate and behavior in the environment as well as the approaches for their efficient removal from the environment.

In this study, degradation of the SARS-CoV-2 antiviral substance nirmatrelvir by two advanced oxidation processes: UV-C/H_2O_2 and UV-C/$S_2O_8^{2-}$, was investigated. The influence of two process parameters: the pH value of the solution and the concentration of the oxidant (H_2O_2 or $S_2O_8^{2-}$) on the process efficiency was studied. Degradation kinetics was evaluated and the optimal degradation conditions determined.

Keywords: SARS-CoV-2, nirmatrelvir, UV-C/H_2O_2, UV-C/$S_2O_8^{2-}$, degradation

We gratefully acknowledge on the financial support from Croatian Science Foundation through the project *Environmental Aspects of SARS-CoV-2 Antiviral Substances* (EnA-SARS; IP-2022-10).



ULTRAZVUČNA RAZGRADNJA CIJANURNE KISELINE NAKON PROČIŠĆAVANJA VODE SOLIMA KLORIRANIH IZOCIJANURATA

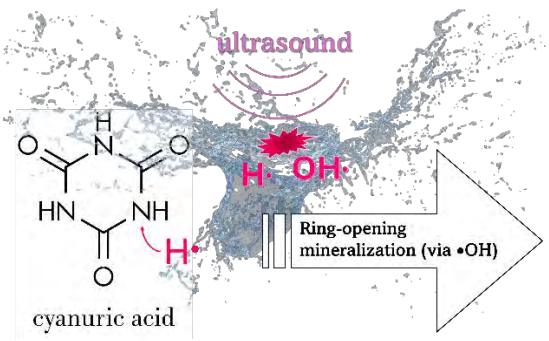
ULTRASONIC DECOMPOSITION OF CYANURIC ACID AFTER WATER PURIFICATION WITH SALTS OF CHLORINED ISOCYANURATES

Ivana Grčić, Lucija Radetić

Sveučilište u Zagrebu Geotehnički fakultet, Hallerova aleja 7, 42000 Varaždin

Ultrazvučna razgradnja cijanurne kiseline (dalje: CYA) predstavlja novi aspekt pročišćavanja voda, ključan za smanjenje koncentracije CYA koja se ispušta u okoliš, ali i smanjenje štetnih učinaka kloriranih organskih spojeva zaostalih nakon dezinfekcije vode, posebno u bazenima i industrijskim postrojenjima. Klorirani izocijanurati, poput natrijevog diklorizocijanurata (NaDCC), koriste se kao izvor slobodnog klora za dezinfekciju vode, ostavljajući CYA kao nusproizvod. S aspekta tehnologije pročišćavanja, visoke koncentracije CYA mogu smanjiti učinkovitost klora kao dezinfekcijskog sredstva, stvarajući potrebu za njenim uklanjanjem ili razgradnjom, dok s aspekta zaštite okoliša, višak CYA dovodi do bioakumulacije i biomagnifikacije, pogotovo zbog vrlo visoke otpornosti na razgradnju. U ovom radu, polazeći od hipoteze da CYA podliježe razgradnji pod djelovanjem $H^{\bullet}$ radikala, istraživana je ultrazvučna razgradnja CYA u vodenim otopinama, budući da akustična kavitacija dovodi do stvaranja više vrsta slobodnih radikala u vodi. Eksperimenti su provedeni u šaržnom reaktoru s ultrazvučnom sondom (100 W, 20 kHz) uz stalno hlađenje. CYA i produkti razgradnje analizirani su LC/Q-TOF/MS tehnikom. Preliminarnim istraživanjima utvrđena je razgradnja CYA i smanjenje njenog sadržaja u vodi te je potvrđena hipoteza da su često zanemareni $H^{\bullet}$ radikali ključni za razgradnju CYA, molekule otporne na $OH^{\bullet}$ radikale.

Ključne riječi: cijanurna kiselina, NaDCC, akustična kavitacija



OPTIMISATION OF THE PRODUCTION PROCESS OF POLYHYDROXYALKANOATES FROM WASTE BIOMASS

Karlo Grgurević[1], Martina Miloloža[1], Krešimir Stublić[2], Vesna Ocelić Bulatović[1], Jasmina Ranilović[3], Šime Ukić[1], Matija Cvetnić[1], Marinko Markić[1], Stela Jokić[4], Krunoslav Aladić[4], Drago Šubarić[5], Tomislav Bolanča[6], Dajana Kučić Grgić[1]

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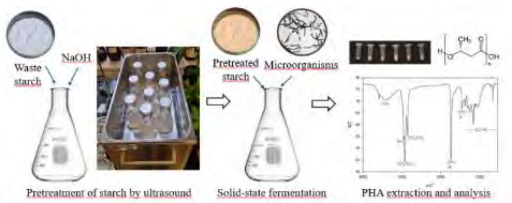
The plastic used today is predominantly synthetic and non-biodegradable. To address this issue, science is focused on producing natural, eco-friendly polymers such as polyhydroxyalkanoates (PHA). This study utilized waste starch as a substrate for PHA production. Microorganisms such as *Leukonostoc* sp., *Bacillus licheniformis*, *Citrobacter freunbii*, *Staphylococcus lentus*, *Cryptococcus humicola*, *Geotrichum klebahnii*, and *Candida krusei* were isolated from starch. To enhance starch digestion, the starch was pretreated using ultrasonic waves at varying intensities (1-3 W mL^{-1}), durations (30, 60, 90 minutes), and NaOH concentrations (0.01 M, 0.05 M, 0.1 M) at 20 °C. The goal was to identify the optimal pretreatment method for maximizing PHA production. Solid-state fermentation of pretreated starch was conducted with microorganisms isolated from starch over 7 days at room temperature. PHA was extracted using chloroform and a 4% sodium hypochlorite solution. FTIR analysis confirmed the presence of the synthesized PHA polymer.

Keywords: polyhydroxyalkanoate, microorganisms, starch, pretreatment, fermentation

This research was conducted as part of the project „*Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products*" (NPOO.C3.2.R3-I1 .04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).



RE-ANALYSIS OF VOLATILE ORGANIC COMPOUNDS IN AIR SAMPLES USING THERMAL DESORPTION UNITS

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Volatile organic compounds (VOCs) are known as environmental pollutants due to their carcinogenicity and mutagenicity consequently leading to adverse health effects as well as their influence on atmospheric chemistry. They are gaseous compounds emitted into the atmosphere from biogenic and anthropogenic sources. Due to their volatile nature, it is necessary to apply a suitable sample preparation method for their analysis. Thermal desorption is a method that replaces classic extraction methods, without the use of solvents, making the preparation process more environmentally friendly. In this research, for the determination of 19 VOCs thermal desorption coupled with gas chromatography and mass spectrometry detector (TD-GC/MS) was used. Thirty real air samples were collected at multi-bed tubes packed with a combination of porous polymer, graphitised carbon black, and carbonised molecular sieved. TD-GC/MS instrument enables the return of the analyte to the tubes after the GC/MS analysis is performed, and thus the sample can be re-analysed. The aim was to determine the achievability and efficiencies of air sample re-analysis in recollection mode, for five consecutive cycles in the same tubes. It was taken that the first cycle of analysis represents 100% of the total amount of the sample, while for the other four cycles, sample reductions were calculated in percentages. For all VOCs similar values for individual cycles were observed, therefore the average values and relative standard deviations for compounds expressed in percentages are presented. For the second cycle, the efficiency of the re-analysis was 50.0 ± 5.6 % of the total amount, for the third cycle 30.6 ± 8.2 %, for the fourth cycle 20.7 ± 10.5 %, and for the fifth cycle was 14.4 ± 13.1 %.

Keywords: desorption cycles, air pollution, VOCs

This study was supported by the affiliated institution, European Regional Development Found project KK.01.1.1.02.0007 (Rec-IMI), the Horizon Europe (EDIAQI project #101057497), and the European Union – Next Generation 533-03-23-0006 (EnvironPollutHealth).

THE USE OF FOOD INDUSTRY BY-PRODUCTS FOR DRUG FORMULATION

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By reducing the amount of waste generated during production, it is possible to minimize the negative impact of human activities on the environment. The food industry belongs to the group of polluters. However, food production generates by-products with high nutritional value. Such by-product are white potato starch and cheese whey [1,2]. Starch is increasingly used in the drug formulation for capsule production and cheese whey as a cheap source of lactose and protein in the pharmaceutical industry.

In this study, crystalline celecoxib was used as a model drug, which was characterized as a cohesive powder with bioavailability problems [3-5]. Potato starch was used for filament development and 3D printing of capsules using fused deposition modelling (FDM). The threads used for printing, were prepared at 100 °C by hot melt extrusion in a twin-screw extruder. Cheese whey, on the other hand, was used in wet granulation along with celecoxib on a laboratory mixer-granulator Diosna P1-6. The morphological structure of obtained materials was determined using a scanning electron microscope and the thermal behaviour was determined using thermogravimetric analysis and differential scanning calorimetry. Powder properties were also monitored on the prepared granules of cheese whey and celecoxib.

Keywords: potato starch, cheese whey, by-products, raw material

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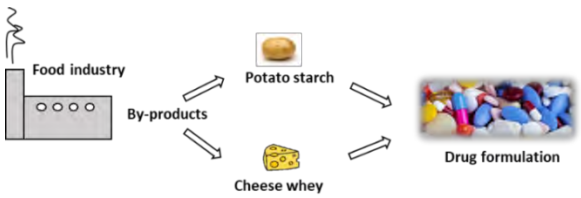

DETERMINATION OF ECOTOXICITY OF SARS-CoV-2 ANTIVIRAL DRUGS

Tijana Jezerčić, Martina Miloloža, Kristina Bule Možar, Viktorija Martinjak, Matija Cvetnić, Marinko Markić, Lidija Furač, Tomislav Bolanča, Šime Ukić, Dajana Kučić Grgić

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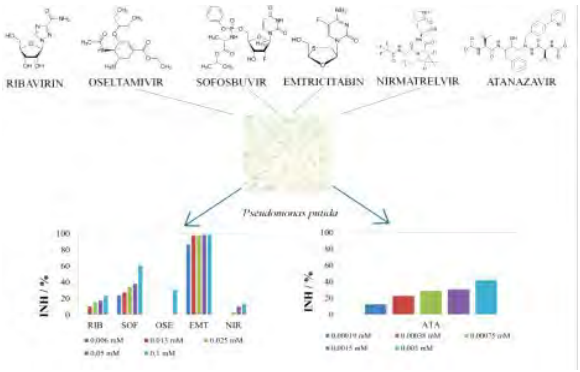
Coronavirus, caused by the SARS-CoV-2 virus, attacks the respiratory tract and has resulted in over 7 million deaths. Antivirals, essential for treating many diseases, can negatively affect aquatic organisms. This study investigated the effects of SARS-CoV-2 antivirals on the bacterium *Pseudomonas putida*. The experiment involved adding equal amounts of bacterial suspension to solutions with varying concentrations of ribavirin, emtricitabine, sofosbuvir, oseltamivir, nirmatrelvir, and atazanavir. The concentrations for the antivirals ribavirin, emtricitabine, sofosbuvir, oseltamivir and nirmatrelvir were: 0.006 mmol/L, 0.013 mmol/L, 0.025 mmol/L, 0.05 mmol/L and 0.1 mmol/L, while the concentrations of the antiviral atazanavir were as follows: 0.00019 mmol/L, 0.00038 mmol/L, 0.00076 mmol/L, 0.0015 mmol/L and 0.0030 mmol/L. After 16 hours, the number of live bacterial colonies (CFU) was counted. Results showed that higher antiviral concentrations led to greater inhibition of bacterial growth. Emtricitabine at 0.1 mmol/L was the most toxic, inhibiting bacterial growth by 98.94%, while nirmatrelvir at the same concentration inhibited growth by only 13.71%.

Keywords: ecotoxicity, SARS-CoV-2, antiviral drugs, *Pseudomonas putida*

The authors would like to acknowledge the financial support of the Croatian Science Foundation through the project entitled Environmental Aspects of SARS-CoV-2 Antiviral Substances (EnA-SARS, IP-2022-10-2822).



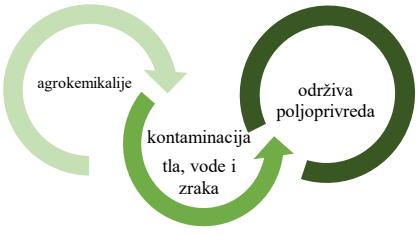
UTJECAJ AGROKEMIKALIJA NA PRIRODU I OKOLIŠ
IMPACTS OF AGROCHEMICALS ON THE NATURE AND ENVIRONMENT

Gabriella Kanižai Šarić, Vesna Rastija, Ivana Majić

Sveučilište Josipa Jurja Strossmayera u Osijeku, Fakultet agrobitehničkih znanosti Osijek, Vladimira Preloga 1, 31000 Osijek

Agrokemikalije su neizostavan dio intenzivnih sustava poljoprivredne proizvodnje. Njihova primjena donosi brojne koristi, ali isto tako izaziva zabrinutost zbog štetnog učinka na zdravlje ljudi, prirodu i okoliš. Neodgovorna primjena agrokemikalija može rezultirati kontaminacijom tla, vode i zraka te imati štetne učinke na ekosustav. Agrokemikalije mogu imati dugoročne posljedice na ekološku ravnotežu te uzrokovati neželjeno uništavanje korisnih, neciljanih organizama. Osim toga, dugotrajna izloženost agrokemikalijama može uzrokovati ozbiljne kronične zdravstvene probleme kod ljudi različitih skupina toksičnosti poput karcinogenosti, hormonalnih i neuroloških promjena i drugih oboljenja. Agrokemikalije mogu suprimirati rast i razvoj pojedinih grupa mikroorganizama, što može utjecati na biogeokemijski ciklus hranjivih elemenata i kvalitetu tla. Neprikladna uporaba agrokemikalija može dovesti do smanjenja biološke raznolikosti tla što može dugoročno narušiti plodnost i produktivnost tla te negativno utjecati na lanac prehrane. Uz sve veću svijest o ekološkoj održivosti, postoji pomak prema metodama uzgoja koje smanjuju potrebu za agrokemikalijama poput integriranog pristupa upravljanja poljoprivrednom proizvodnjom. Stalno usavršavanje poljoprivrednih metoda i tehnologija, ključno je za postizanje održivog poljoprivrednog sustava kako bismo očuvali ravnotežu mikrobiote tla, zaštitili prirodu i okoliš te osigurali sigurnost hrane. Razvoj i primjena alternativa agrokemikalijama mogu značajno doprinijeti zaštiti prirodne sredine i zdravlja ljudi u budućnosti.

Ključne riječi: pesticidi, toksičnost, mikrobiom tla, održiva poljoprivreda



SASTAV OBORINE NA PODRUČJU REPUBLIKE HRVATSKE U 2023. GODINI

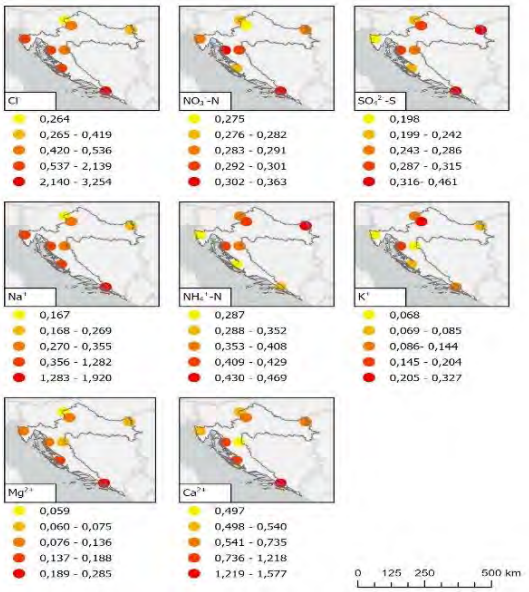
CHARACTERISTICS OF PRECIPITATION IN THE TERRITORY OF THE REPUBLIC OF CROATIA IN 2023

Ante Koštić, Ivana Ćosić, Dario Dabić, Ksenija Kuna

Državni hidrometeorološki zavod, Ravnice 48, 10000 Zagreb

Sastav i koncentracija glavnih iona (Cl^-, NO_3^--N, SO_4^{2-}–S, Na^+, NH_4^+-N, K^+, Mg^{2+}, Ca^{2+}) te kiselih komponenti u oborini daju nam podatke o izvorima emisija onečišćenja koji doprinose kvaliteti oborine. Ispitivanja su provedena na osam postaja Državne mreže za trajno praćenje kvalitete zraka pokrivajući značajan dio Republike Hrvatske. Praćenje kvalitete oborine na postajama državne mreže u Republici Hrvatskoj, u 2023. godini, ukazuje na prisutnost minimalnih količina štetnih tvari kisele depozicije. Kod mjernih postaja koje su bliže moru dominiraju ioni koji potječu iz morskog aerosola (ioni natrija, klorida, magnezija i sulfata), dok se na mjernim postajama koje se nalaze u blizini poljoprivrednih aktivnosti nailazi na ione koji potječu iz umjetnih gnojiva (primarno dušikovi spojevi, kalij te sekundarno kalcij, sumpor i magnezij). Kod mjernih postaja koje se nalaze u krškom kraju vidljiva je dominacija kalcijevih iona.

Ključne riječi: oborina, glavni ioni u oborini, kiselost oborine, kvaliteta zraka



Geografska razdioba srednjih godišnjih koncentracija glavnih iona u oborini

INFLUENCE OF EVERZOL BLACK B DYE CONCENTRATION ON ITS ADSORPTION ON THE POWDERED ACTIVATED CARBON

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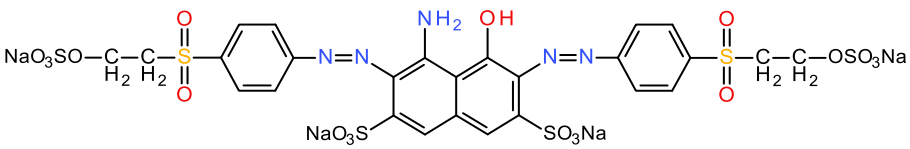
Textile industry is one of the most environmentally intensive industry because it generates huge quantities of wastewater. The water is mainly used for application of chemicals onto the fibres, as well as washing and rinsing of the final products. The composition of wastewater depends on many factors: type of raw material used and type of textile material produced, chemicals used, type of treatment process, etc. Wastewater very often contains an excess of dyes that are added during the dyeing and printing of textiles and therefore pose a major risk to the environment. Among the various classes of dyes, reactive dyes are among the most widely used and contribute significantly to the colouration of textile wastewater. Although many of the dyes used in dyeing processes are non-toxic, dyed effluents have harmful and negative aesthetic and biological effects on water systems, so the dyes should be removed from the effluents. Among the numerous decolourisation methods, adsorption has proven to be an efficient and cost-effective water treatment method that does not lead to the formation of harmful substances.

The aim of this work was to investigate the adsorption efficiency of commercially available powdered activated carbon for the removal of the dye Everzol Black B in a concentration range from c_0 = 300 mg dm^{-3} to c_0 = 500 mg dm^{-3}. Isothermal batch adsorption study was carried out at 45 (±1) ºC with 0.1 g of activated carbon for periods ranging from 30 minutes to 16 hours when equilibrium was reached. Additional aims were to determine the adsorption rate and adsorption mechanism and to calculate standard Gibbs free energy of adsorption to determine if adsorption process is spontaneous.

Keywords: textile wastewaters, Everzol Black B, isothermal adsorption, activated carbon, adsorption kinetics



Chemical structure of Everzol Black B

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) IN PM_{10} AT AN URBAN MEASURING STATION IN ZAGREB: A RANDOM FOREST REGRESSION ANALYSYS

Nikolina Račić[1], Gordana Pehnec[1], Ivana Jakovljević[1], Zdravka Sever Štrukil[1], Mario Lovrić[2,3]

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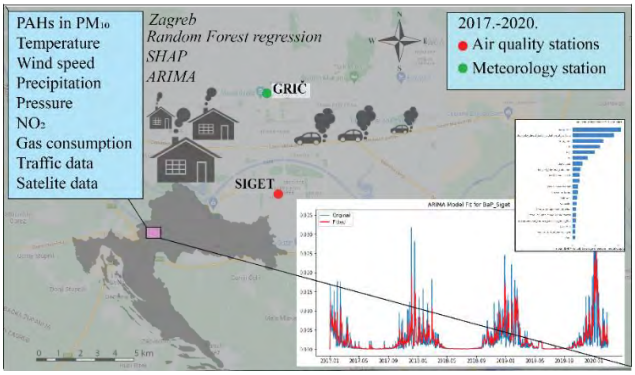
This study analyzes polycyclic aromatic hydrocarbons (PAHs) concentrations in Zagreb from 2017 to 2020, excluding the COVID-19 lockdown period, to understand the impact of meteorological parameters, satellite data, traffic, and heating on PAH levels. A Random Forest regression model and SHapley Additive exPlanations (SHAP) identified minimum temperature, average temperature, and satellite data as significant factors affecting PAH concentrations. Additionally, a seasonal ARIMA (SARIMA) model was applied to capture the seasonal patterns and forecast future PAH concentrations. The findings also revealed the strong influence of traffic on urban PAH concentrations.

Keywords: air pollution, PAHs, Random Forrest, SARIMA, SHAP

This study was supported by the affiliated institution, European Regional Development Found project KK.01.1.1.02.0007 (Rec-IMI) and the European Union – Next Generation 533-03-23-0006 (EnvironPollutHealth).



BIOMASS BURNING AIR POLLUTION IN CONTINENTAL CROATIA

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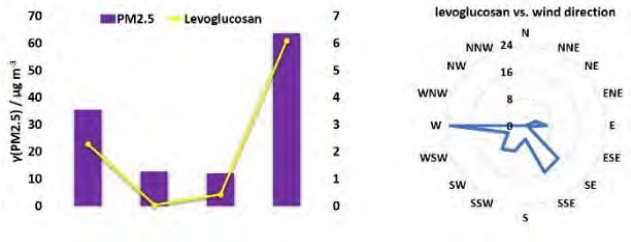
Most air pollution studies in Croatia indicate that, besides traffic, biomass burning is a major contributor to overall air pollution. Due to incomplete combustion, biomass type, and burning regime, a variety of pollutants such as particulate matter, some gases, organic and inorganic compounds, and metals are emitted into the atmosphere. However, because these species often share mutual sources, the biomass burning contribution to air pollution is typically determined using statistical techniques or modelling. Recently, anhydrosugars have been confirmed and accepted as unique tracers. These dehydrated monosaccharides, namely levoglucosan, mannosan, and galactosan, are formed exclusively during cellulose and hemicellulose pyrolysis. This research focuses on determining anhydrosugars levels at a suburban background station in continental area, where wood is widely used for residential heating, agricultural activities are prevalent, and metal and wood industries are in close proximity. For that purpose, daily samples of particulate matter smaller than 2.5 µm ($PM_{2.5}$) were collected over a 30-day period for each season in 2022. Results showed the average levels of $PM_{2.5}$ were the highest during winter (63.6 µg/m³), followed by spring (35.3 µg/m³), summer (12.5 µg/m³), and autumn (11.9 µg/m³). Levoglucosan was the most dominant compound in every season, reaching the highest values during winter, with an average of 6.1 µg/m³ and a maximum of 22.5 µg/m³. The highest contribution of levoglucosan in $PM_{2.5}$ (8.2%) was also registered during winter. Meteorological data revealed the highest levoglucosan levels during winds from the W, SSE, or SE directions.

Keywords: particulate matter, anhydrosugars, levoglucosan, seasonal variations

This study was performed using the facilities and equipment funded within the European Regional Development Fund project KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health", and KK.06.2.1.02.0001 "AIRQ – Expansion and Modernisation of the National Network for Continuous Air Quality Monitoring". This study was funded by the European Union – Next Generation EU (Program Contract of 8 December 2023, Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006)-EnvironPollutHealth.



TOXICITY ASSESSMENT OF COUMARIN-1,2,4-TRIAZOLES ON HONEYBEES (*Apis mellifera*)

Domagoj Šubarić, Maja Karnaš, Dejan Agić, Vesna Rastija

Josip Juraj Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, 31000 Osijek

Climate change and extensive plant protection agent usage have contributed to pollinator species' rapid decline. The biggest concern and focus is the conservation of honeybee populations (*Apis mellifera*). Recently, the new 1,2,4-triazole coumarin derivatives were synthesized for use as potential plant protection agents by utilizing green chemistry principles [1]. To reduce the number of honeybees subjected to *in vivo* testing two toxicity prediction software were used [2,3]. The software that were used, implemented the principles of artificial intelligence and structural alert-based systems for a valuable screening assessment of toxicity specifically for honeybees. *In vivo* acute oral toxicity test was conducted by following the OECD guidelines for the testing of chemicals [4]. A total of ten 1,2,4-triazole coumarin derivatives were selected for the experiment based on their possible toxic effect on honeybees, as well as positive and negative control groups, respectively. For an insecticide standard, a commercially available pesticide that contains spinosad as an active agent was used. All compounds were dissolved in a regular sugar syrup feed following OECD guidelines. Compared to the pesticide standard, none of the tested compounds exhibited significantly higher mortality rates, making them potential non-toxic plant protection agents.

Keywords: 1,2,4-triazole coumarin derivatives, honeybees, toxicity, screening

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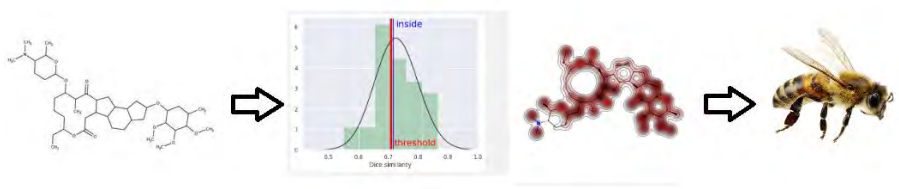

DETERMINATION OF ECOTOXICITY AND PHYTOTOXICITY OF PHENOL, RHODANIDE AND CYANIDE

Ana Tutić[1], Pamela Bubaš[2], Donna Danijela Dragun[2], Leona Kuzmić[2], Lorenna Stanić[2], Martina Miloloža[2], Matija Cvetnić[2], Marinko Markić[2], Šime Ukić[2], Dajana Kučić Grgić[2]

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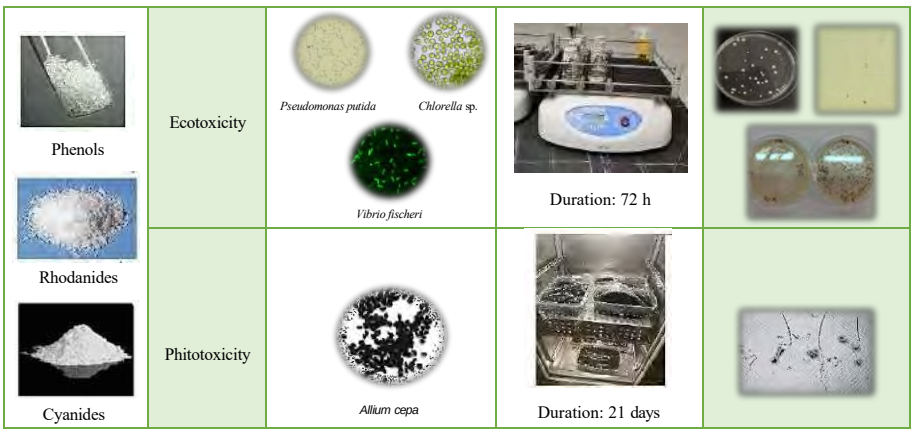
This study investigated the ecotoxicity and phytotoxicity of phenol, rhodanide, and cyanide on various test organisms: the marine bacterium *Vibrio fischeri*, the bacterium *Pseudomonas putida*, the microalgae *Chlorella* sp., and onion seeds *Allium cepa*. The tested concentrations were 1 mg/L, 10 mg/L, 25 mg/L, 50 mg/L, 75 mg/L, and 100 mg/L. *Vibrio fischeri* showed the highest sensitivity, with a bioluminescence inhibition of 99.81% at the highest cyanide concentration. *Chlorella* sp. experienced a maximum growth inhibition of 55.26% after 72 hours of phenol exposure, while *Pseudomonas putida* had an inhibition of 46.97%. Rhodanide inhibited the growth of *Pseudomonas putida* by 59.17% and *Chlorella* sp. by 71.43%. Cyanide caused a 42.27% growth inhibition in *Pseudomonas putida* and a 70.59% inhibition in *Chlorella* sp. at 100 mg/L after 72 hours. In the 21-day seed germination test with *Allium cepa*, cyanide showed the strongest toxic effect, significantly inhibiting root growth. Overall, all tested substances were toxic, with varying sensitivity among the organisms. *Chlorella* sp. and *Pseudomonas putida* were more sensitive to rhodanide, *Vibrio fischeri* was most sensitive to cyanide, and cyanide was the most toxic to *Allium cepa* seeds.

Keywords: ecotoxicity, phytotoxicity, phenol, rhodanide, cyanide



BIOSOPRTION OF AMOXICILLIN FROM WASTEWATER ON BIOCHAR FROM BUCKWHEAT HULLS

Natalija Velić[1], Marija Stjepanović[1], Ružica Mijatović[1], Zita Šereš[2], Nikola Maravić[2], Marek Wrobel[3], Marcin Jewiarz[3]

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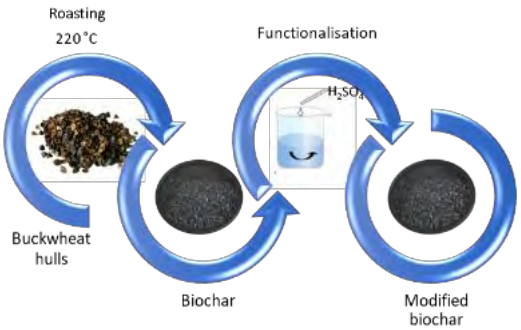
Amoxicillin is a widely used antibiotic that is effective against a range of bacterial infections. However, due to its extensive use and poor biodegradability, it is often found as a contaminant in water bodies. Buckwheat hull-based biochar functionalized with H_2SO_4 was investigated for the removal of amoxicillin (AMX) from model solutions and synthetic wastewater. Batch experiments were performed to investigate factors such as biosorbent concentration (1 – 10 g dm^{-3}), contact time (15 – 360 min), initial AMX concentration (5 – 100 mg dm^{-3}) and pH (2 – 12). Higher concentrations of biosorbent increased the amount of AMX adsorbed per unit mass and increased the overall percentage of AMX removal. Higher initial AMX concentrations (5 – 30 mg dm^{-3}) resulted in more AMX adsorbed per unit mass, probably due to the greater driving force of the adsorbate on the biosorbent, while at initial AMX concentrations of 40 and 100 mg dm^{-3} the biosorption efficiency decreased. AMX biosorption was more effective in synthetic wastewater than in AMX model solutions, and both the Freundlich and Langmuir models described the biosorption process well. The kinetics followed a pseudo-second order model rather than a pseudo-first order model.

Keywords: amoxicillin, biochar, buckwheat hulls, biosorption, wastewater



IDENTIFICATION AND SCREENING OF HYDROCARBON-DEGRADING BACTERIA IN SOIL

Marija Vuković Domanovac[1], Barbara Bertović[2], Monika Šabić Runjavec[1]

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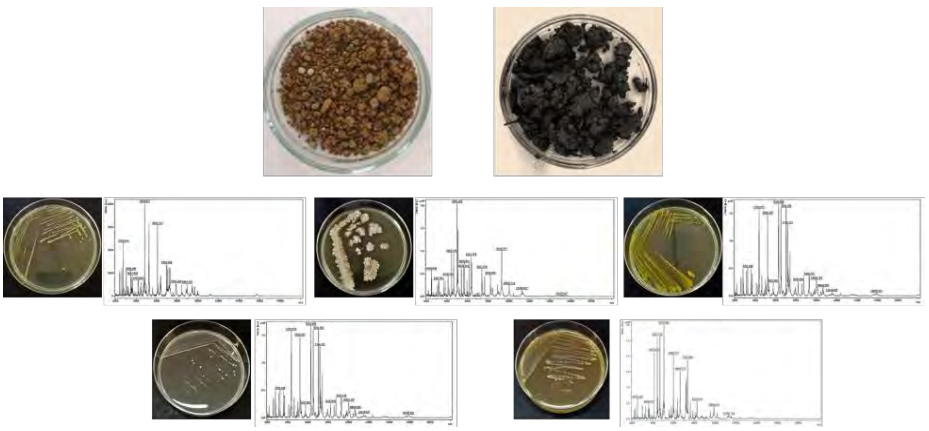
Soil is a non-renewable component of the environment and is essential for all life forms on this planet. Oil is the most important source of energy for various industries and daily life. Soil contamination by oil from various sources disrupts ecosystems, contaminates water, harms human health and reduces agricultural productivity. Bioremediation technology is recognized as an effective, safe and economical soil remediation technique. Microorganisms exposed to oil contamination have developed adaptive mechanisms to survive in a stressful environment and exhibit high biodegradation rates.

In this study, bacterial screening of two different soil samples contaminated with oil was performed. Microbiological and MALDI-TOF analyses were performed to characterize the bacterial isolates. The results show that a microbial community from the genera *Lysobacter*, *Bacillus*, *Cupriavidus*, *Pseudomonas* and *Novosphingobium* is present in oil-contaminated soils. The identification and screening of hydrocarbon-degrading bacteria is a promising solution to improve the effectiveness and sustainability of bioremediation.

Keywords: oil contamination, soil, identification, screening, hydrocarbon-degrading bacteria



THE IMPACT OF MINING ON SOIL QUALITY IN THE SURROUNDINGS OF THE KIZHNICA MINE

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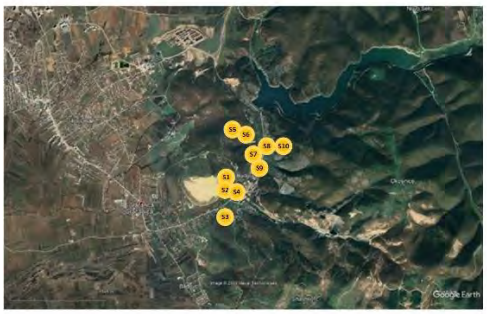
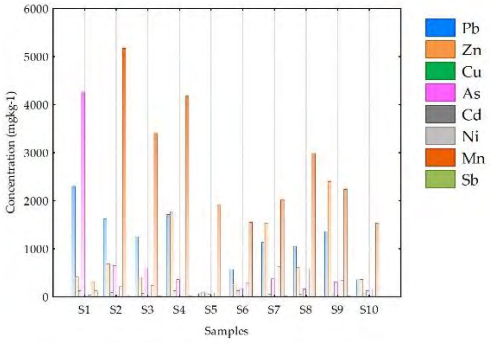
Mining sector is one of the most important economic sectors in the Republic of Kosovo, and one of the most important mines is the Kizhnica mine (Gracanica municipality), a mine rich in lead and zinc ores. In addition to the positive effects, the activities associated with mining also have negative side effects, such as the generation and disposal of large amounts of mining waste and pollution of the surrounding agricultural land. As part of this study, an analysis of the distribution of heavy metals in agricultural soils in the surroundings of three large landfills associated with the Kizhnica mine was carried out. Soil samples were taken from 10 locations and the concentration of Pb, Zn, Cu, As, Cd, Ni, Mn and Sb was determined. The results indicated pollution of the soil by heavy metals. A cluster analysis was carried out, which revealed the anthropogenic nature of the soil pollution.

Keywords: Kizhnica mine, soil, heavy metals, pollution





9. SUSRET MLADIH KEMIČARA

9th MEETING OF YOUNG CHEMISTS

PRIRODNA KOZMETIKA
NATURAL COSMETICS

Ivana Avrić, Katarina Dobrić, Đurđevka Pecikozić
Tehnička škola Nikole Tesle Vukovar, Blage Zadre 4, 32010 Vukovar

Kozmetika nas prati na svakom koraku, no malo tko se pita kakav učinak ima na našu kožu i okoliš. Sastojci kozmetičkih proizvoda koje nanesemo na sebe, a koža ih ne apsorbira, kao što su antibiotici iz gelova za umivanje, mineralna ulja iz mlijeka za tijelo, silikoni iz sredstava za njegu kose, plastične kuglice iz pilinga za stopala, umjetni mirisi iz parfema, otpadnim vodama dospijevaju u okoliš. Prirodna kozmetika sadrži sastojke biljnog ili životinjskog podrijetla. Dobiva se isključivo fizikalnim, mikrobiološkim i enzimskim metodama. Cilj rada je izraditi prirodne proizvode koji ne sadrže tvari štetne za naš organizam i okoliš, te ukazati kako pojedinac može doprinijeti održivom razvoju. Kombiniranjem lako dostupnih sirovina i uporabom jednostavnog pribora pripremljeni su kruti parfemi, puder, sapun, balzam za usne i pjenušave kuglice. Proizvodi prirodne kozmetike potiču kožu na stvaranje vlastite masnoće koja štiti organizam i održava prirodnu pH- vrijednost kože što je pogodno za dobre bakterije koje nas štite od infekcija, a istodobno zadržava prirodnu vlažnost u gornjim slojevima kože, sprječavajući isušivanje. Ova vrsta kozmetike ne sadrži mineralna ulja, sintetičke antibiotike, boje, mirise, parabene i druge tvari štetne za organizam i okoliš.

Ključne riječi: prirodna kozmetika, koža, okoliš, održivi razvoj

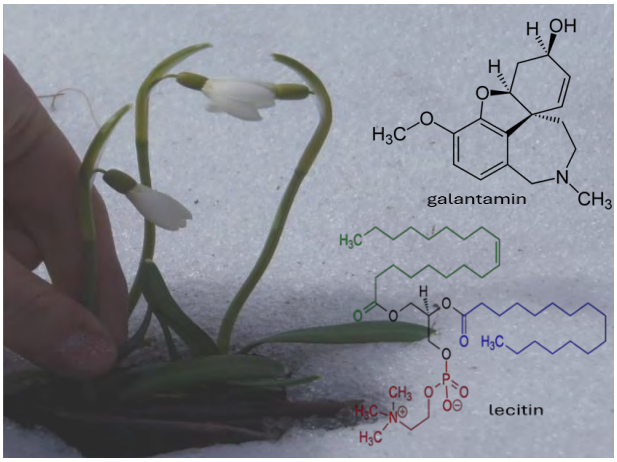
VISIBABA, NJEŽNA I SNAŽNA
SNOWDROP, GENTLE AND STRONG

Tamara Marija Bevetek, Ivan Pavao Jagarčec, Iva Linzi, Andrija Šćuka, Lorena Leskovar, Tamara Tkalec-Car, Petra Novak Mlinarić

Graditeljska, prirodoslovna i rudarska škola, Hallerova aleja 3, 42000 Varaždin

Visibaba ili *Galants nivalis* višegodišnja je biljka, dugih zelenih listova, karakterističnog izgleda cvijeta s tri veće vanjske bijele latice i tri manje unutarnje koje na vrhu imaju zelenu pjegu. Ova zakonom zaštićena biljka i sama se štiti od nepoželjnih insekata. Naime u svom sastavu sadrži jedinstvenu vrstu lecitina (glikoprotein) koja ima insekticidno djelovanje. U lukovici visibabe nalazi se i alkaloid galantamin. Ova nevjerojatna molekula djeluje na ljudski mozak održavajući ga budnim. Blokira djelovanje enzima koji razgrađuje acetilkolin koji je glavni prijenosnik impulsa pri radu neurona. Visoka razina acetilkolina sprečava gubitak pamćenja pa se galantamin koristi u liječenju Alchaimerove bolesti i proučavanju lucidnog sna. Cilj našeg rada bio je proučiti, a zatim i primijeniti načine kojima bi u školskom laboratoriju izolirali te dvije tvari. S obzirom da je visibaba zakonom zaštićena biljka pridržavali smo se zakona Ministarstva zaštite okoliša koji određuje dozvoljene količine za osobne svrhe. Lecitin smo ekstrahirali iz stabljike i listova pomoću smjese otapala kloroforma i metanola. U dobivenom ekstraktu prisutnost lecitina kvalitativno smo dokazali otopinom kadmijevog klorida koji stvara bijeli talog kompleksnog spoja lecitina s kadmijem. Galantamin smo izolirali iz lukovica visibabe ekstrakcijom pomoću etanola. Nakon pročišćavanja iz ekstrakta kristalizirali su bijelo-žuti kristali čiju smo čistoću ispitali tankoslojnom kromatografijom. Proučavajući ovu nježnu biljku i tvari koje sadrži upustili smo se u svijet važnih bioloških spojeva s kemijskog, biološkog, medicinskog i prehrambenog stajališta. Uvidjeli smo da u prirodi možemo pronaći rješenja za mnoge zdravstvene i ekološke probleme modernog čovjeka.

Ključne riječi: visibaba, izolacija, galantamin, lecitin



Acinetobacter baumannii, STVARNI UZROČNIK SMRTI KOD COVID-19 POZITIVNIH PACIJENATA?

Acinetobacter baumannii, THE REAL CAUSE OF DEATH IN COVID-19 POSITIVE PATIENTS?

Aurora Bićanić[1], Elena Požar[1], Jasminka Žiža[1], Tatjana Tot[2]

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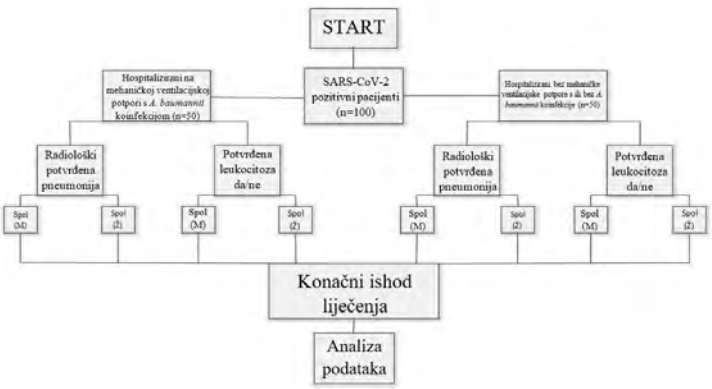
[2]*Opća bolnica Karlovac, Ul. Andrije Štampara 3, 47000 Karlovac*

Virus SARS-CoV-2 uzrokuje bolest COVID-19 koja se širi kapljično i aerosolom [1], čije su epidemije česte na dječjim odjelima i domovima za starije. Virus je zbog toga čest uzročnik bolničkih infekcija, posebice kod osoba oslabljenog imunološkog sustava [2]. Mnogi COVID-19 pacijenti koji su obolijevali od pneumonije liječeni su na mehaničkoj ventilaciji. Pneumonija je infekcija i kao najteža upalna bolest dišnoga sustava može biti uzrokovana brojnim i različitim mikroorganizmima. Posljedica te infekcije je koinfekcija gram negativnom bakterijom, *Acinetobacter baumannii.* Ova koinfekcija učestala je u skupini navedenih pacijenata starijih od 55 godina. U prvom dijelu eksperimenta analizirani su podaci navedenih pacijenata, dok se u drugom dijelu ispituje otpornost bakterije na pojedine antibiotike. Cilj rada je dokazati rasprostranjenost *Acinetobacter baumannii* u bolničkim odjelima i njezin utjecaj na smrtnost starijih pacijenata.

Ključne riječi: COVID-19, pneumonija, kontaminacija, *Acinetobacter baumannii,* smrtnost

[1] J. Begovac i sur., Klinička infektologija, Medicinska naklada, Zagreb, 2019, str. 596-606.
[2] H. Wilde et al., *BMJ (Clinical research ed.)* 382 (2023) e073639.



Grafički prikaz obrade pacijenata

ODREĐIVANJE SADRŽAJA ASKORBINSKE KISELINE U TABLETI VITAMINA C

DETERMINATION OF ASCORBIC ACID CONTENT IN VITAMIN C TABLETS

Sara Bulajić, Katarina Barišić, Sandro Džambo Jelušić, Marko Tomas

Katolički školski centar „Don Bosco" Žepče, Gimnazija, Stjepana Radića bb, 72230 Žepče, Bosna i Hercegovina

Askorbinska kiselina prisutna je u različitim količinama u biljnim i životinjskim vrstama. Ljudski organizam ne može sam sintetizirati askorbinsku kiselinu, te je ovisan o vanjskim izvorima askorbinske kiseline (vitamin C), što su u prvom redu povrće i voće te razni farmaceutski pripravci. Askorbinska kiselina rabi se kao jedan od sastojaka za proizvodnju analgetika, vitaminskih proizvoda, za tretman pića, kao dodatak životinjskoj hrani i dr. Tržišni uzorci vitamna C osim askorbinske kiseline sadrže pomoćne i druge aktivne tvari. Cilj ovog istraživanja bio je odrediti ukupni sadržaj askorbinske kiseline u tržišnim uzorcima (tableta) različitih proizvođača. Tijekom istraživanja korištena je klasična kiselo-bazna titracija, potencijometrijska kiselo-bazna titracija i jodometrijska titracija.

Ključne riječi: askorbinska kiselina, vitamin C, kiselo-bazna titracija, jodometrijska titracija

UTJECAJ OTAPALA NA SADRŽAJ BIOAKTIVNIH KOMPONENTI I ANTIOKSIDATIVNU AKTIVNOST EKSTRAKATA *Achillea Millefolium* L.

EFFECT OF SOLVENTS ON CONTENT OF BIOACTIVE COMPONENTS AND ANTIOXIDATIVE ACTIVITY OF Achillea Millefolium L. *EXTRACTS*

Anđela Čivljaku[1], Nika Pranjić[2], Ella Tomić[1], Mariela Zovko[2], Luka Đulabić[1], Emir Horozić[1], Slavica Jukić[2]

[1]Katolički školski centar „Sveti Franjo" Tuzla, Klosterska 10, 75000 Tuzla, BiH

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Stolisnik ili hajdučka trava (*Achillea millefolium* L.) je biljka koja se u tradicionalnoj medicini najčešće koristi za liječenje astme, bronhitisa, gastritisa te drugih bolesti dišnog i probavnog sustava. Povijesno gledano, ova biljna vrsta je prošla brojne analize biološkog djelovanja u *in vitro* i *in vivo* uvjetima. U ovom radu ispitan je sadržaj polifenola i flavonoida, te antioksidativno djelovanje ekstrakata stolisnika koji su pripremljeni maceracijom u vodi, etanolu i metanolu, te smjesi voda:metanol i voda:etanol. Za ispitivanje antioksidativnog kapaciteta korištena je DPPH i FRAP metoda. Biljni materijal je sakupljen na dvije lokacije, u Tuzli i Žepču. Ispitivanja su pokazala da ekstrakti pripremljeni u smjesi voda:metanol imaju najveću koncentraciju bioaktivnih komponenti i ujedno najveći antioksidativni kapacitet. Najslabiji ekstrakcijski učinak imao je etanol, za čiji je ekstrakt evidentiran najniži sadržaj polifenola i flavonoida. S obzirom na geografsko podrijeklo, biljni materijal sakupljen u okolici Žepča pokazao se učinkovitijim u inhibiciji slobodnih radikala i s većim sadržajem bioaktivnih komponenti.

Ključne riječi: maceracija, polifenoli, flavonoidi, DPPH, FRAP

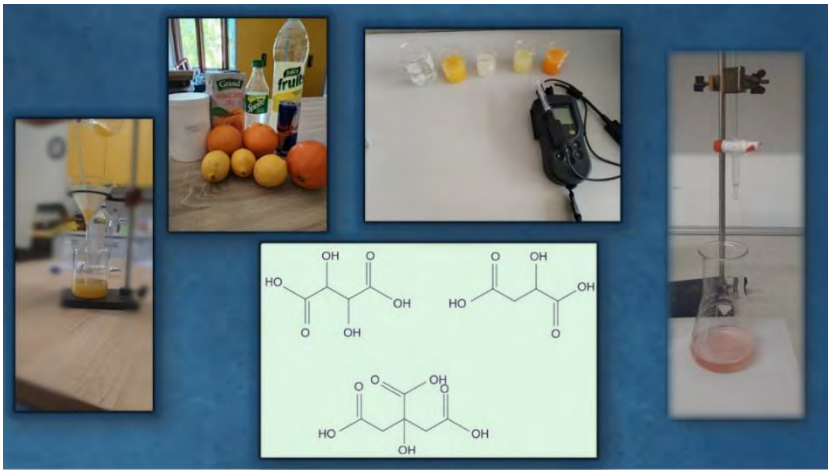
KISELINE U VOĆU I VOĆNIM SOKOVIMA
ACIDS IN FRUIT AND FRUIT JUICES

Dora Čolaković, Luka Kristić, Maja Radić

Gimnazija Matije Antuna Reljkovića, Trg bana Josipa Šokčevića 1, 32100 Vinkovci

U voću i povrću prisutni su organski spojevi (jabučna, vinska, limunska kiselina, taurin) koji im daju prirodnu kiselost. Organske kiseline su u voću i povrću prisutne u vrlo malim količinama, a mogu se nalaziti u slobodnom obliku ili u obliku soli. U prehrambenoj industriji ove se kiseline koriste prvenstveno kao aditivi za poboljšanje okusa, ali i kao konzervansi za stabilnost određenih namirnica. Iako je kiseliji medij pogodniji za djelovanje konzervansa, s druge strane kiselost sokova ima vrlo veliku ulogu pri eroziji zubi. Cilj ovog rada bio je odrediti kiselost odabranog voća i voćnih sokova dostupnih na tržištu. Uzorcima je pomoću pH metra izmjerena pH vrijednost, a potom su uzorci titrirani otopinom natrijevog hidroksida uz fenolftalein kao indikator. Računski je određen udio vinske, jabučne i limunske kiseline u svakom uzorku, a dobiveni rezultati su pokazali da od svih ispitivanih uzoraka sok svježeg limuna sadrži najviše organskih kiselina.

Ključne riječi: limunska kiselina, jabučna kiselina, vinska kiselina, titracija



ZELENI ADSORBENSI
GREEN ADSORBENTS

Mateja Dobrinić Đirlić, Dorijan Jakopić, Jelena Perković
Tehnička škola Sisak, M. Cvetkovića 2, 44000 Sisak

Adsorbensi su tvari s velikom aktivnom površinom, a ta površina postiže se finim usitnjavanjem ili velikom pozornošću. Adsorpcija je uzrokovana privlačnim silama između površine adsorbensa i molekula u plinu ili otopini koja se adsorbiraju, stoga je popraćena oslobađanjem topline. U većini materijala, svi atomi i molekule su povezani kemijskim vezama (bilo ionskim, kovalentnim ili vezama metalne prirode) s drugim atomima i molekulama. Izuzetak predstvljaju atomi koji se nalaze na površini materijala, koji nisu potpuno okruženi drugim atomima. Iz tog razloga, površinski atomi imaju manji ili veći anfitet u formiranju veza s nekim drugm atomom koji se nađe u blizini. Kao jedan od najčešćih adsorbensa koristi se aktivni ugljen, koji je po svojoj prirodi hidrofoban, amorfan i velike specifične površine, a s adsorbatom uglavnom tvori slabe van der Waals-ove veze zbog čega ima veliku sposobnost regeneracije i ponovne upotrebe Danas se sve više okreće zelenim adsorbensima jer su ekonomski prihvatljivi, ekološki su i imaju veliku moć adsorpcije. Zeleni adsorbensi dobivaju se iz metaluruške industrije, e-otpada, prehrambene industrije, poljoprivrednog otpada, prerade drveta i prirodnih materijala. U ovom radu radila se usporedba adsorpcije octene kiseline na aktivnom ugljenu i zelenom adsrobensu, odnosno troski dobivene kao nus produkt iz metalurške industrije. Eksperiment je proveden na način da se octena kiselina zadanih koncentracija prelije preko aktivnog ugljena i troske, te se nakon 24 sati titrira otopinom NaOH poznate koncentracije uz prisustvo fenolftaleina. Iz dobivenih rezultata vidljivo je da je učinkovistost adsorpcije troske pogodna za adsoprciju octene kiseline, te se pretpostavlja da je moguća zamjena za aktivni ugljen što je potrebno potvrditi dodatnim ispitivanjima.

Ključne riječi: adsorpcija, octena kiselina, aktivni ugljen, zeleni adsorbensi, troska

PREDVIĐANJE UTJECAJA TEMPERATURE NA POJEDINE FENOLOŠKE FAZE BILJKE PRIMJENOM STATISTIČKIH MODELA

STATISTICAL MODELLING OF PLANT PHENOLOGICAL PHASES IN CORRELATION WITH AIR TEMPERATURE

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[1]*Gimnazija Vukovar, Šamac 2, 32000 Vukovar*

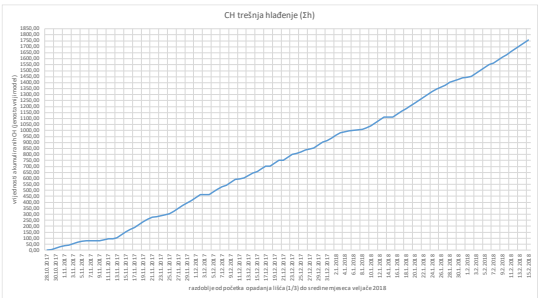
[2]*Sveučilište Josipa Jurja Strossmayera u Osijeku, Fakultet agrobiotehničkih znanosti Osijek, Vladimira Preloga 1, 31000 Osijek*

Temperatura okoline biljke jedna je u nizu značajnih faktora koji će u velikoj mjeri utjecati na fenološke faze biljke. Dugotrajan period neuobičajeno toplog ili hladnog vremena utjecati će na fenološke faze biljke. Do danas je razvijeno nekoliko modela koji služe za „prognozu" fenoloških faza. Prvi se model računanja suma hladnih (Chill Units/Chill Hours) i toplih jedinica (Heat Units) pojavio početkom 70. godina prošlog stoljeća, a cilj mu je bio predvidjeti, na temelju mjerenja temperature zraka, pojedine fenološke faze biljke, posebno pupanje nakon osjetljive faze zimskog mirovanja. Modeli predviđanja fenofaza se najčešće primjenjuju na voćne vrste. Svaka voćna vrsta ima specifične zahtjeve suma hladnih i toplih jedinica potrebnih za pojedinu fenofazu, a što je temelj Utah modela. U ovom se radu posebno dotičemo specifičnih potreba trešnje i jabuke za akumulacijom i hladnih jednica (CH/CU) ali i hladnih porcija (CP) primjenjujući dinamički model. Danas su poznati okvirni iznosi hladnih jedinica/porcija za trešnju i jabuku te se rezultati ovog istraživanja mogu usporediti s istima. Akumulacija hladnih jedinica tijekom procesa mirovanja značajno je povezana s biokemijskim procesima te utječe na ostale fenofaze.

Ključne riječi: statistički modeli analize, temperatura, fenološke faze biljke

Kriterij vrijednosti hladnih jedinica kao funkcija satne vrijednosti temperature zraka

Temperatura (°C)	CU
≤ 1.4	0
1.4 – 2.4	0.5
2.5 - 9.1	1
9.2 – 12.4	0.5
12.5 – 15.9	0
16.0 – 18.0	- 0.5
≥ 18.0	- 1



Primjer grafičkog prikaza akumuliranih CH, hladnih jedinica za trešnju u ovisnosti o minimalnoj i maksimalnoj dnevnoj temperaturi

CIJANOTIPIJA
CYANOTYPE

Filip Galović, Đurđevka Pecikozić

Tehnička škola Nikole Tesle Vukovar, Blage Zadre 4, 32010 Vukovar

Cijanotipija je fotografska tehnika otkrivena krajem 19. stoljeća. Početkom 20. stoljeća stekla je veliku popularnost u reprodukciji tehničkog crteža, građevinskih planova i patenata kao i u umjetnosti. Cilj ovoga rada je primjeniti tehniku cijanotipije za preslikavanje slike sa predloška na papir i tkaninu. Reakcijom amonijevog citrata i željezovog(III) hidroksida sintentiziran je amonijev željezov(III) citrat koji u smjesi s kalijevim heksacijanoferatom(III) pod djelovanjem UV- zraka daje željezov(III) heksacijanoferat(II) poznat kao berlinsko modrilo, pariško plavo ili prusko plavo. Intenzitet plave boje i jasnoća slike ovise o vremenu izloženosti i količini UV- zračenja. Što je izloženost UV- zrakama dugotrajnija i što je intenzitet UV- zračenja jači redukcija Fe^{3+} iona u Fe^{2+} ione je potpunija, nastaje veća količina željezovog(III) heksacijanoferata(II) i plava boja je intenzivnija. Napretkom tehnologije, krajem 20. stoljeća, cijanotipija gubi svoju popularnost u tehničkim i znanstvenim poljima i koristi se ponajviše u umjetničke svrhe što ostaje i do danas.

Ključne riječi: cijanotipija, UV- zrake, redukcija, berlinsko modrilo

UTJECAJ TEMPERATURE I pH-VRIJEDNOSTI NA STABILNOST ANTOCIJANINA ZA PRIMJENU U BOJOM SENZIBILIZIRANIM SOLARNIM ĆELIJAMA

INFLUENCE OF TEMPERATURE AND pH ON STABILITY OF ANTHOCYANINS FOR APPLICATION IN DYE-SENSITIZED SOLAR CELLS

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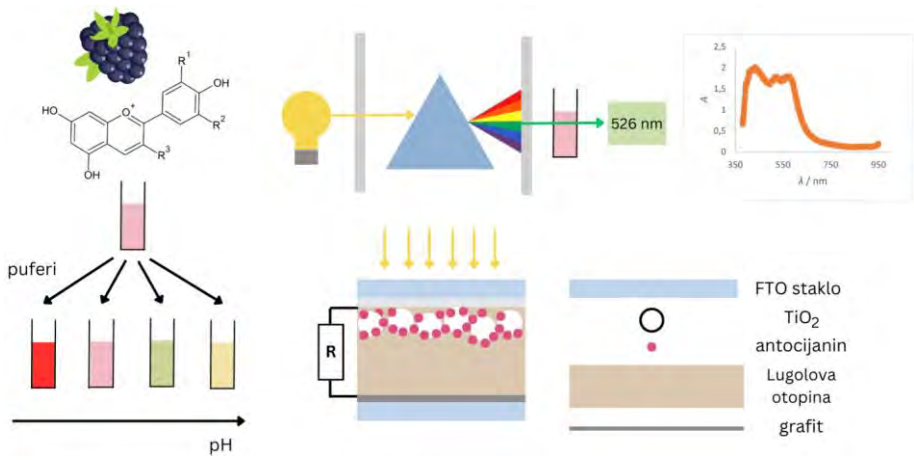
Antocijanini su biljni pigmenti koji se zbog sposobnosti apsorpcije svjetlosti koriste u bojom senzibiliziranim solarnim ćelijama (eng. *Dye-Sensitized Solar Cells* – DSSC). Njihovu stabilnost, tj. sposobnost zadržavanja kemijske strukture, narušavaju promjene određenih čimbenika, čime se ograničava rad DSSC-a [1]. U istraživanju je spektrofotometrijski ispitan utjecaj temperature (8 °C - 80 °C) i pH-vrijednosti (2,15 - 8,20) na stabilnost antocijanina iz ploda kupina. Vis spektri uzoraka u promijenjenim uvjetima temperature i pH-vrijednosti snimljeni su spektrofotometrom nakon određenih vremenskih intervala temperiranja, no posebno je promatrana apsorbancija pri 526 nm. Rezultati istraživanja u navedenim intervalima mjerenja pokazali su veću stabilnost antocijanina pri nižim pH-vrijednostima i temperaturama. Radu solarne ćelije pogodovat će hlađenje i zakiseljavanje boje.

Ključne riječi: antocijanin, temperatura, pH-vrijednost, spektrofotometrija, DSSC

[1] N. Y. Amogne, D. W. Ayele, Y. A. Tsigie, *Mater Renew Sustain Energy* 9 (2020) 23.



PRIJE UPOTREBE PAŽLJIVO PROČITAJTE UPUTE O LIJEKU

FOLLOW THE DIRECTIONS ON THE MEDICINE LABEL CAREFULLY

Kiara Lemac, Lea Samardžić, Borna Fodor Pravdić, Stella Špoljarić, Antonija Milić, Sanja Pavlović Šijanović, Davor Šijanović

Gimnazija Vukovar, Šamac 2, 32000 Vukovar

Cilj ovog istraživanja je ispitati otpornost bakterija na antibiotike, odnosno, kako na rast bakterija utječe prekomjerno ili nedovoljno korištenje odabranih antibiotika. Istraživanje je provedeno u laboratoriju Odjela za biologiju Sveučilišta Josip Juraj Strossmayer u Osijeku gdje su izolirane kolonije bakterija *Escherichie coli*, te su podvrgnute mjerenju otpornosti na određene koncentracije dva odabrana antibiotika. Provedena je i anketa u kojoj su ispitanici odgovarali na pitanja vezana uz korištenje antibiotika.

Glavna ideja ovog istraživačkog rada je osvijesti ljude, a ponajviše djecu i mlade, o učincima antibiotika na ljudski organizam, te istaknuti važnosti valjanog i propisanog uzimanja antibiotika uslijed bolesti. Ustanovljeno je kako su sustavi bakterija, antibiotika i čovjeka vrlo nestabilni, te kako bi vrlo brzo mogli prerasti u nekontrolirane sustave, ako se ne pronađu ograničavajući elementi. Uzeti su uzorci iz naše sredine (mobiteli) te su uspješno izolirane bakterijske kulture (*Escherichia coli*). Dokazano je kako su bakterije pri relativno visokim koncentracijama vrlo otporne na antibiotike ampicilin i gentamicin. Nažalost, antibiotik Ampicilin koji se najčešće prepisuje za upale mokraćnog mjehura, pokazao se kao gotovo neučinkovit u određenim koncentracijama.

Važno je napomenuti da je racionalna upotreba antibiotika ključna u borbi protiv otpornosti bakterija na antibiotike. To uključuje propisivanje i uzimanje antibiotika samo kada je to stvarno potrebno, te pridržavanje uputa o doziranju i trajanju terapije.

Ključne riječi: bakterije, *Escherichia coli*, antibiotici, otpornost bakterija, neadekvatna uporaba antibiotika

BIOLOŠKE METODE UKLANJANJA SINTETSKIH BOJILA
BIOLOGICAL METHODS OF REMOVAL OF SYNTHETIC DYES

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Porast svjetske populacije konzumerizam i moderan stil života u mnogim zemljama uzrokuje nastanak i nagomilavanje sve veće količine otpadnih materijala. Posebno treba istaknuti tekstilnu industriju, te kao rezultat razvoja tekstilne industrije, onečišćenje otpadnih voda. Cilj ovog rada usmjeren je na sintetska bojila, a s obzirom kako sintetska bojila negativno utječu na prirodu i okoliš, ovim smo istraživanjem ukazali na biološke metode kojima se ista mogu ukloniti. Konvencionalne metode nisu u potpunosti učinkovite niti ekološki prihvatljive. Biološke metode obuhvaćaju dekolorizaciju upotrebom gljiva ili drugih mikroorganizama, adsorpciju na živoj ili mrtvoj biomasi, te upotrebu sustava za bioremedijaciju. U ovom radu istražena je sposobnost obezbojenja različitih sintetskih bojila na čvrstim supstratima pomoću gljiva bijelog truljenja roda Trametes. Istražena je sposobnost obezbojenja dva sintetska bojila (kisela narančasta i malahitno zelenilo) pomoću dvije vrste odabranih gljiva bijelog truljenja: T. Versicolor i Pleurotus eryngi. Gljive su uzgajane na agarnim pločama s dodatkom bojila u koncentracijama 10, 30 i 50 mg L^{-1} te je praćen njihov rast i obezbojenje bojila tijekom 30 dana uzgoja pri 27 ºC. Istraživanje je provedeno u laboratoriju Prehrambeno-tehnološkog fakulteta u Osijeku. Malahitno zelenilo snažno je inhibiralo rast obje vrste, ali su i obje vrste pokazale dobru sposobnost obezbojenja ovog bojila, što je vidljivo iz velikog indeksa obezbojenja (promjer obezbojenja/promjer kolonije). Sposobnost obezbojenja azo bojila pokazali su sojevi obje vrste što nam je odličan pokazatelj učinkovitosti ove metode uklanjanja sintetskih bojila.

Ključne riječi: gljive, sintetska bojila, zona rasta, zona obezbojenja, biološke metode

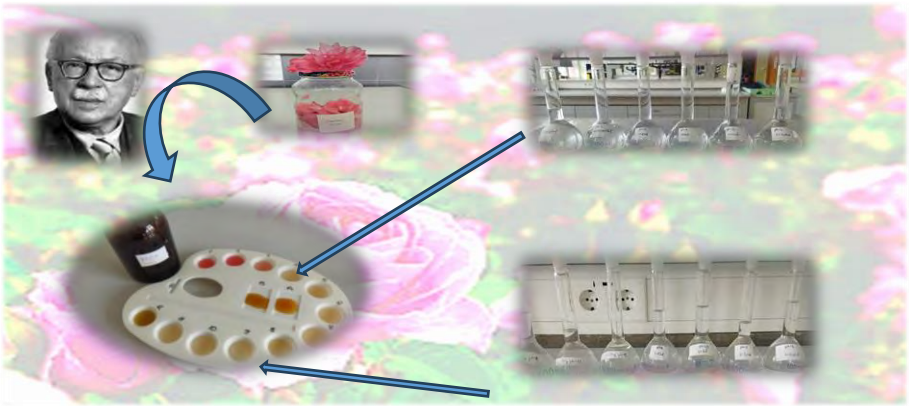
PRIRODNI KISELINSKO-BAZNI INDIKATORI
NATURAL ACID-BASE INDICATORS

Katarina Lukić, Lea Lukić, Đurđevka Pecikozić

Tehnička škola Nikole Tesle Vukovar, Blage Zadre 4, 32010 Vukovar

Antocijani su u vodi topljivi biljni pigmenti, nalaze se u vakuoli biljnih stanica. Ubrajajaju se u skupinu flavonoida i osjetljivi su na promjenu pH-vrijednosti. Cilj ovoga rada je pripremiti alkoholne ekstrakte svježih latica ruža i ispitati kako promjena pH-vrijednosti utječe na promjenu boje ekstrakta.
Lavoslav Ružička uživao je u svom ružičnjaku stoga su za ovaj rad odabrani cvjetovi ruža kao izvor antocijana, prirodnog kiselinsko-baznog indikatora. Antocijan je iz svježih latica ruža crvene, ružičaste i svjetlo ružičaste boje ekstrahiran 70% etanolom. Otopine različitih pH-vrijednosti pripremljene su razrjeđivanjem otopine HCl (aq), c = 0,1 mol/L i otopine NaOH (aq), c = 0,1mol/L. pH-vrijednosti pripremljenih otopina mjerene su pomoću pH-metra, model HQ40d. Seriji otopina čija se pH-vrijednost kreće od 1 do 14 dodan je ekstrakt svježih latica ruža i promatrana je promjena boje ovisno o pH-vrijednosti otopine. Promjena boje ekstrakta latica ruže ovisno o pH-vrijednosti najuočljivija je primjenom ekstrakta latica ružičaste ruže. U području pH-vrijednosti od 3 do 4 boja ekstrakta latica ruže promjenila se iz ružičaste u narančasto-smeđu boju. Intenzitet narančasto–smeđe boje se pojačava u pH-području od 4 do 12, a pri pH-vrijednosti 13 ekstrakt latica ruže poprimio je crveno-smeđu boju. Ekstrakt latica ruže mjenja boju ovisno o pH-podrujućju stoga se može uvrstiti u prirodne kiselinsko-bazne indikatore. Prirodni kiselinsko-bazni indikatori su lako dostupni, jeftini, nemaju štetan utjecaj na zdravlje i okoliš.

Ključne riječi: antocijanini, pH-vrijednost, boje, indikatori



PRIMJENA PRIRODNIH KISELINSKO-BAZNIH INDIKATORA

APPLICATION OF NATURAL ACID-BASE INDICATORS

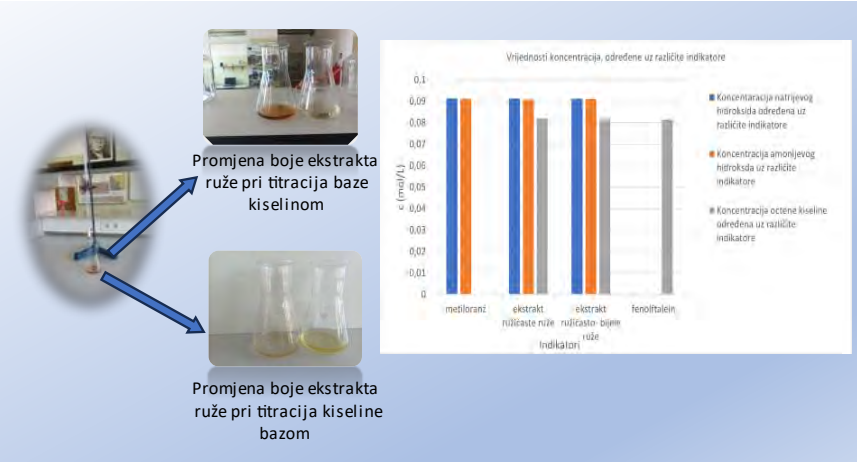
Milica Malić, Đurđevka Pecikozić

Tehnička škola Nikole Tesle Vukovar, Blage Zadre 4, 32010 Vukovar

Volumetrija je kvantitativna analitička metoda i ima široku primjenu u kemijskim analizama. Temeljena je na mjerenju volumena titranta potrebnog za potpunu reakciju s analitom. Titrant ili standardna otopina je otopina poznate koncentracije, a analit je tvar koja se određuje. Postupak određivanja analita titrantom je titracija. Za određivanje završne točke titracije rabe se odgovarajući indikatori. Cilj ovoga rada je ispitati točnost i preciznost kiserlinsko–baznih titracija primjenom prirodnih indikatora.

Urađene su titracije slabe baze jakom kiselinom, jake baze jakom kiselinom i slabe kiseline jakom bazom. Završna točka titracije određena je primjenom komercijalnih kiselinsko-baznih indikatora, fenolftaleina i metiloranža i primjenom prirodnog kiselinsko-baznog indikatora, alkoholnog ekstrakta svježih latica ruže. Volumen titranta potreban za potpunu reakciju s analitom određen primjenom komercijalnog kiselinsko-baznog indikatora gotovo je identičan volumenu titranta utrošenog primjenom alkoholnog ekstrakta svježih latica ruže. Na osnovu utrošenog volumena titranta, izračunate su koncentracije otopina kiselina i baza. Dobiveni rezultati su točni i precizni. Primjenom prirodnih kiselinsko-baznih indikataora kao što je alkoholni ekstrakt svježih latica ruže može se odrediti završna točka titracije u acidimetriji i alkalimetriji.

Ključne riječi: volumetrija, završna točka titracije, indikatori, prirodni indikatori

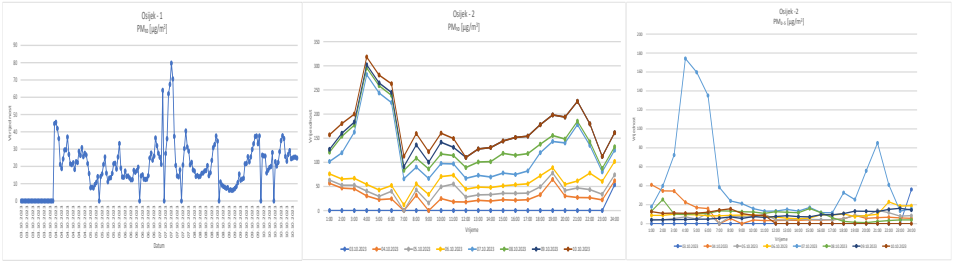


„PLASTIKA GORI – ZEMLJA TRPI“
„PLASTIC BURNS - EARTH SUFFERS“

Igor Prašnikar, Ljiljana Vidović, Leona Vukelić, Dino Poznić
Tehnička škola i prirodoslovna gimnazija Ruđera Boškovića, Vukovarska 209, 31000 Osijek

Cilj je ovog rada analizirati utjecaj požara plastike na okoliš i ljudsko zdravlje, s posebnim naglaskom na lokalni slučaj požara u tvrtki Drava International Osijek. Povod za ovakvu aktivnost bio je katastrofalni požar u skladištu plastike, u pogonu tvrtke Drava International. Dana 4. listopada 2023., u ranim jutarnjim satima građane Osijeka uzbunila je SMS dojava o alarmantnom požaru plastike. Crni gusti dim širio se južno od Osijeka nekoliko dana, a proširio se 50-ak kilometara južno, na svu sreću nošen snažnim sjevernim vjetrom južno od grada, prema nekoliko mjesta južno od Osijeka. Postavili smo hipotezu da izgaranje plastike uzrokuje oslobađanje štetnih tvari koje imaju negativan utjecaj na okoliš i ljudsko zdravlje. Istraživačko pitanje na koje smo željeli potražiti odgovor, je koje su specifične tvari oslobođene tijekom požara i kakav je njihov utjecaj na okoliš i zdravlje. Čestice kao što su formaldehid, acetaldehid, ksilen, stiren, fenoli, etilen, benzen, dioksin, bifenil, nastaju pri gorenju plastike, su glavna onečišćavala, te je njihovo praćenje u atmosferi važno kao pokazatelj stanja kvalitete zraka. Kao glavnu metodu rada, proveli smo praćenje stanja kakvoće zraka na mjernim postajama u gradu. Navedene čestice praćene su kao ukupne lebdeće čestice u zraku, manje od 2 i 10 µm izražene u $\mu g/m^3$ zraka, a njihove vrijednosti prikazane su putem grafikona. Rezultati praćenja kakvoće zraka, smo grafički prikazali, te iz toga izveli zaključak. Navedeni požar nije imao veliki utjecaj na kakvoću zraka u gradu, prvenstveno zbog jakog sjevernog vjetra, koji sve produkte nosio južno od grada. Na kraju, predlažemo što bi trebalo poduzeti kako se ovakve ekološke katastrofe u budućnosti ne bi više događale, a ako se i dogode, njihovi negativni učinci trebali bi se čim više smanjiti.

Ključne riječi: požar, plastika, onečišćavala, monitoring



ODREĐIVANJE SADRŽAJA VITAMINA C U VOĆNIM SOKOVIMA

DETERMINATION OF VITAMIN C CONTENT IN FRUIT JUICES

Monika Rakoci, Valentina Štetić, Maja Radić

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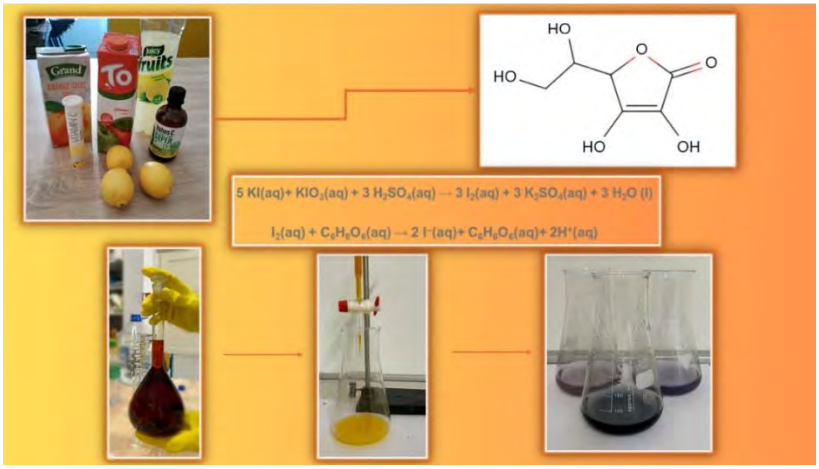
Vitamin C je vrlo snažan antioksidans prisutan u voću i povrću. Može pomoći u zaštiti drugih vitamina (vitamin A i vitamin E) od štetnih utjecaja oksidacije. Vitamin C djeluje na funkciju središnjeg živčanog sustava, stimulira funkciju endokrinih žlijezda, pojačava funkciju jetre i apsorpiju željeza. Važno je naglasiti da vitamin C poboljšava imunitet, proces detoksikacije i obnavlja tkiva. Kontinuirani nedostatak vitamina C može dovesti do skorbuta, abnormalnosti kostiju i zuba. Cilj ovog rada bio je odrediti sadržaj vitamina C u odabranom voću i voćnim sokovima dostupnim na tržištu titracijom otopinom joda i škrobom kao indikatorom. Dobivene vrijednosti uspoređene su s literaturno dostupnim vrijednostima i navedene su preporučene dnevne doze unosa vitamina C. Iako mnogo voća i povrća sadrži vitamin C, rezultati su pokazali da svježe voće sadrži veću količinu vitamina C od industrijski prerađenih voćnih sokova, a od odabrnih uzoraka najveći udio vitamina C sadrži sok svježeg limuna.

Ključne riječi: vitamin C, titracija, indikator



ODREĐIVANJE SADRŽAJA VITAMINA C *U BILJNOM MATERIJALU* *DETERMINATION OF THE VITAMIN C IN PLANT MATERIAL*

Borna Svrtan[1], Roko Pavlović[1], Silvija Krnić[1], Elvira Kovač-Andrić[2], Nikolina Filipović[2]

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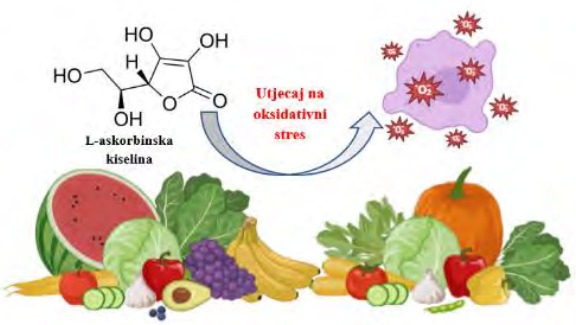
[2]*Sveučilište Josipa Jurja Strossmayera u Osijeku, Odjel za kemiju, Ulica cara Hadrijana 8/A, 31000 Osijek*

Vitamin C, poznat i kao L-askorbinska kiselina, spoj je topljiv u vodi te je prisutan u voću i povrću. Prvi je sintetski dobiven vitamin. Sudjeluje kao reducens u brojnim biološkim procesima. Važan je za sintezu kolagena i karnitina te za metabolizam masnih kiselina. Najjači je antioksidans među vitaminima topljivim u vodi. Određivanje sadržaja vitamina C ključno je za procjenu nutritivne kvalitete različitih prehrambenih proizvoda [1]. U ovom istraživanju učenici su koristili metode za kvantifikaciju vitamina C pomoću otopine škroba i joda. Eksperiment je uključivao titraciju uzoraka koji sadrže vitamin C otopinom joda uz škrob kao indikator, do pojave tamnoplavog obojenja (kompleks škroba i trijodidnog iona). Rezultati pokazuju izvedivost i preciznost ove metode za određivanje sadržaja vitamina C, čineći ga vrijednim alatom za analizu hrane i kontrolu kvalitete. Ovaj praktični rad omogućio je učenicima primjenu teorijskog znanja i razumijevanja kako se vitamin C može izolirati i kvantificirati u stvarnim uzorcima. Učenici su povezali školsko znanje s realnom primjenom, poput određivanja kvalitete hrane i razumijevanja nutricionističkih informacija.

Ključne riječi: antioksidansi, askorbinska kiselina biljni materijal, titracija

[1] A. M. Pisoschi, A. F. Danet, S. Kalinowski, *J. Autom Methods Manag. Chem.* 8 (2008) 937651.



SINTEZA ASPIRINA I KVANTITATIVNA ANALIZA ACETILSALICILNE KISELINE U TABLETI METODOM TITRACIJE

SYNTHESIS OF ASPIRIN AND QUANTITATIVE ANALYSIS OF ACETYLSALICYLIC ACID IN THE TABLET USING THE TITRATION METHOD

Benjamin Bojan Vojković[1], Corina Bilić[1], Ana Ubrekić[1], Leona Alimehaj[1], Kristina Kristek[1], Elvira Kovač-Andrić[2], Nikolina Filipović[2]

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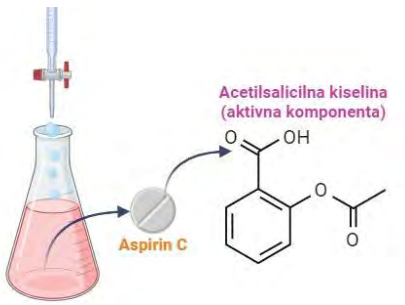
Učenici su iz svakodnevnog života upoznati s brojnim lijekovima koji se često koriste s ciljem snižavanja tjelesne temperature (antipiretici), a da pri tome ne znaju koje su aktivne/djelatne tvari u tim lijekovima. Aspirin ili acetilsalicilna kiselina jedan je od najpoznatijih antipiretika koji se često koristi i kao lijek protiv tromboze te za prevenciju srčanog udara [1]. Cilj rada bio je sinteza acetilsalicilne kiseline iz salicilne kiseline i anhidrida octene kiseline uz prisustvo katalizatora sumporne kiseline te kvantitativna analiza acetilsalicilne kiseline u komercijalno dostupnom izvoru, tableti Aspirina. Dobiveni bijeli, igličasti kristali sintetizirane acetilsalicilne kiseline odvojeni su od matičnice vakuum filtracijom i fotografirani. Za određivanje količine acetilsalicilne kiseline u tableti Aspirina korištena je kiselinsko-bazna titracija vodenom otopinom natrijeva hidroksida uz fenolftalein kao indikator. Istraživanjem je utvrđeno da je sintetizirana acetilsalicilna kiselina čisti spoj. Također je utvrđeno i da je količina acetilsalicilne kiseline u tableti istovjetna količini koja je navedena na komercijalnom pakiranju lijeka Aspirina. Učenici su primijenili školsko znanje o metodama titracije na realnom uzorku Aspirina.

Ključne riječi: acetilsalicilna kiselina, aspirin, titracija, vakuum filtracija

[1] N. Liu, A. Mathews, J. Swanson, R. Mhaskar, A. Mathews, N. Ayoubi, A. S. Mirza, *Open Med.* 8 (2020) 1–10.



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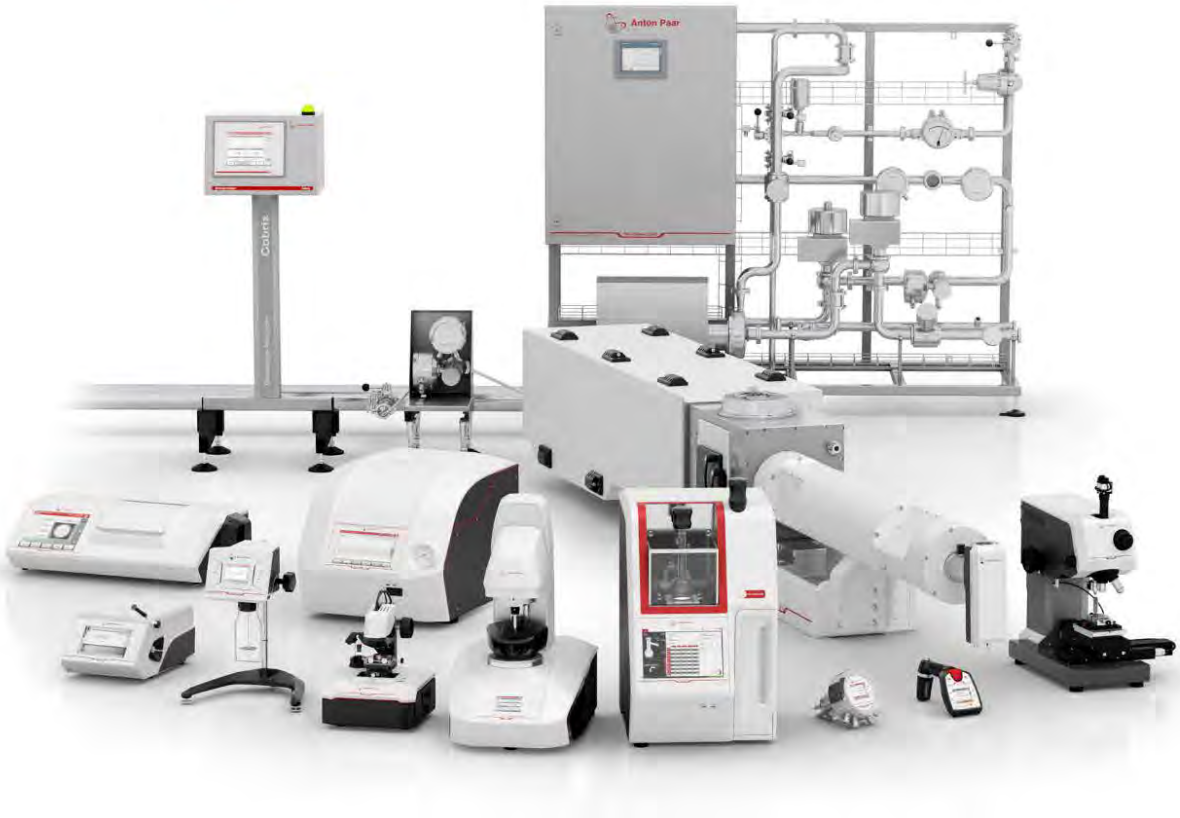

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Naš dinamičan tim stručnjaka uvest će Vas u svijet vodećih svjetskih tehnologija i inovacija i upravo za Vaše potrebe predložiti najbolje rješenje, a prodajni savjetnici s dugogodišnjim iskustvom stoje Vam na raspolaganju za sve informacije vezane za program prodaje instrumenata, potrošnog materijala i rezervnih dijelova te ideja za provedbu projekata.

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PRERADA NUSPROIZVODA I ZDRAVLJE LJUDI I OKOLIŠA

Vjerojatno ste već puno puta čuli da biorazgradivi ostaci i nusproizvodi životinjskog podrijetla nisu otpad i da njihova prerada ima višestruku korist. Skupljanjem otpada i nusproizvoda sprječava se njihovo gomilanje u okolišu te se na taj način čuva okoliš, a i širenje potencijalnih zaraznih bolesti. To je prva, ujedno i najvažnija korist razdvajanja i skupljanja otpada. Druga korist od skupljenih nusproizvoda i otpada je njihova prerada. Preradom se dobivaju novi vrijedni proizvodi te se potiče načelo kružnog gospodarstva. Novi proizvodi mogu se koristiti u različitim industrijama poput kemijske, prehrambene, energetske i u pet food industriji. Ono što je pritom ključno naglasiti je da se pravilnim zbrinjavanjem čuva zdravlje ljudi i životinja te vodi briga o našem okolišu. Stoga je javnozdravstvena uloga ove djelatnosti, njezin glavni i središnji naglasak. Skupljanje nusproizvoda životinjskog podrijetla je neposredna aktivnost na suzbijanju zaraznih bolesti. Bez nje, bez pravovremenog i ispravnog prikupljanja odvoza i zbrinjavanja nusproizvoda, zarazne bi se bolesti mogle nekontrolirano širiti. Zamislimo samo koliko se na dnevnoj razini proizvede otpada po jednoj osobi, dodajmo tome otpad u ugostiteljstvu, prehrambenoj industriji, farmama i slično, i da se sav taj otpad odloži u prirodi, improvizacijski zakopa po poljima, ili spontano baci u rijeke ili jezera itd. Bilo bi to pogubno za zdravlje ljudi i životinja i stanje okoliša. Jednostavno, zaštita zdravlja ljudi i životinja i očuvanje zdravog okoliša preduvjet je svake sigurnosti i budućnosti života uopće.

Kako bi se ideje o ispravnom razdvajanju i o našoj vlastitoj odgovornosti spram otpada koji stvaramo proširile društvom i došle do što većeg broja ljudi, potrebna je trajna edukacija, pozitivni primjeri, prenošenje znanja sa stručne javnosti na sve razine i skupine javnosti i društva. Otvorenošću znanstvene i poslovne zajednice prema okruženju putem edukacija, potporama, organiziranjem i poticanjem različitih ekoloških akcija, stvara se i njeguje kultura i spoznaja o vrijednosti očuvanja prirode kao temeljnog preduvjeta opstanka života. To je najbolji i najuvjerljiviji način vraćanja prirodi i okolišu ono što od njih i dobivamo. I konačno, potvrđuje da priroda svoju cjelovitost i svoje zdravlje može vratiti i sačuvati samo ako s njom surađujemo. Jer ako okoliš ne bude zdrav, neće niti čovjek biti zdrav. Čovjek i okoliš jedino i mogu živjeti i opstati zajedno.

https://www.agroproteinka.hr/

bio-mi
SUSTAINABLE SOLUTIONS

Put Brdo 15, Matulji
https://bio-mi.eu

Bio-mi d.o.o. je mala i srednja tvrtka za istraživanje i razvoj sa sjedištem u Matuljima, posvećena proizvodnji termoplastičnih materijala i proizvoda iz biološkog izvora koji se koriste za proizvodnju primarne i sekundarne ambalaže te poljoprivrednih proizvoda.

Glavne aktivnosti tvrtke uključuju napredni inženjering novih materijala na osnovi biomase i održivih plastičnih materijala. Prvi smo proizvođač certificiranih granulata i proizvoda u Istočnoj i Jugoistočnoj Europi, a ponosno ističemo da smo jedni od malobrojnih proizvođača na svijetu koji će nakon dvije godine analize, u vrlo kratkom roku, ishodovati i TUV certifikat za biorazgradnju u tlu kojim će se svakom poljoprivredniku, tj. korisniku folije za malčiranje, jamčiti potpuna biorazgradnja, bez rizika onečišćenja tla ili kontaminacije usjeva. Upravo iz osjetljivosti proizvoda koji direktno utječe na proizvodnju hrane, sama analiza i proces ishodovanja certifikata je dugotrajan i iznimno temeljit.

Sve znanstveno-istraživačke aktivnosti unutar tvrtke možemo podijeliti na nekoliko područja:

- Inovativni Horizon 2020 i Horizon Europe projekti koji se provode za Europsku komisiju. Unutar tih projekata razvijaju se najsuvremenija (*state-of-the-art*) rješenja koja još ne postoje na tržištu, a koja bi trebala u bliskoj budućnosti zamijeniti proizvode dobivene iz fosilnih izvora.
- Interne aktivnosti u kojima razvijamo vlastite formulacije za proizvodnju materijala i proizvoda za tržište. Skoro svaki proizvod ima biološku alternativu samo treba odabrati kompoziciju materijala koja najbolje odgovara finalnom proizvodu koji želimo proizvesti, a da pritom očuvamo, tj. ne narušimo svojstva
- Privatni znanstveno-istraživački projekti u kojima, u suradnji s klijentima iz raznih područja, razvijamo formulacije za specifičan proizvod koji se treba zamijeniti održivijim

Naše aktivnosti imaju za cilj proizvodnju materijala na biološkoj osnovi koji bi zamijenili materijale iz tradicionalnih, fosilnih izvora, istražujući na taj način biorazgradivost i mogućnost recikliranja bioloških materijala, procjenjujući njihov potencijal, posebno biopolimera i bioplastike.

Osim razvijanja novih sastavnih elemenata (*building blocks*) i materijala na biološkoj osnovi, Bio-Mi pruža usluge savjetovanja i edukacije u području transformacije i reciklaže plastike i ostalih naprednih materijala u gotove proizvode koji su u skladu s ciljevima bioekonomije. Ukratko, želimo pridonijeti održivoj budućnosti i odgovoriti na društvene izazove koji su povećanjem fosilne plastike u sustavu sve veći.

Bio-Mi je jedna od rijetkih tvrtki u Hrvatskoj i ovom dijelu Europe koja je postala punopravna članica Konzorcija bio-industrije (BIC) i nastoji aktivno pridonijeti razvoju bioekonomije u Europi sudjelujući sa ostalim članovima konzorcija na kolaborativnim projektima koji su direktno usmjereni na bioindustriju. Konzorcij bio-industrije omogućava da se dizanjem svijesti potrošača i umreživanjem svih sudionika lanca vrijednosti u inovativne projekte s ambicioznim ciljevima, poveća konkurentnost bio proizvoda, kreiraju radna mjesta u bioindustriji, i u konačnici stvori klimatski–neutralana i resursno učinkovita Europa koja je konkurentna na globalnoj sceni.

EMUS

More than equipment!

VIŠE OD OPREME

U EMUS-u ponosno nudimo širok spektar prilagođenih rješenja za kontrolu kvalitete zahvaljujući našem dugogodišnjem iskustvu i stručnosti. Bez obzira tražite li standardni proizvod ili prilagođeno rješenje, naš tim stručnjaka ovdje je da vam pomogne pronaći pravo rješenje za vašu specifičnu primjenu.

Naša sveobuhvatna ponuda pruža korisnicima rješenje koje će ih podržavati tijekom čitavog procesa. Od instalacije do održavanja, naš koncept je osmišljen kako bi zadovoljili vaše specifične potrebe i napravili razliku u vašem poslovanju. Pouzdajte se u EMUS za sve vaše potrebe u rješenjima za kontrolu kvalitete i opremanje postrojenja, tvornica, inspekcijskih kuća, laboratorija, instituta.

EMUS održava partnerske odnose s vodećim proizvođačima u industriji, što nam omogućuje da našim klijentima ponudimo najbolje sustave za kontrolu kvalitete, mjerenje i usluge. U EMUS-u shvaćamo važnost održavanja visokih standarda kontrole kvalitete u vašem poslovanju. Zato se naš tim posvećuje pružanju inovativnih rješenja. S EMUS-om možete biti sigurni da su vaše potrebe za kontrolom kvalitete u stručnim rukama. Nadogradite svoje procese kontrole kvalitete s nama već danas, i doživite razliku brzo i osobno.

EMUS pruža sustave za kontrolu kvalitete, ispitivanje zahvaljujući bliskim partnerskim odnosima s vodećim proizvođačima u industriji. Naš se tim posvećuje osiguravanju preciznosti i pouzdanosti u svakom sustavu koji isporučujemo, uključujući instalaciju, održavanje i kalibraciju. Nadogradite svoje poslovanje s našim stručnim rješenjima i doživite razliku s EMUS-om.

EMUS je na čelu uvođenja novih tehnologija pružajući pouzdana rješenja za mjerenje svojstva materijala i komponenti. Pouzdajte se u EMUS za rješenja za mjerenje, kontrolu kvalitete i ispitivanja materijala.

S potporom naših partnera, EMUS može biti vaš pouzdani dobavljač novih tehnologija za vas!

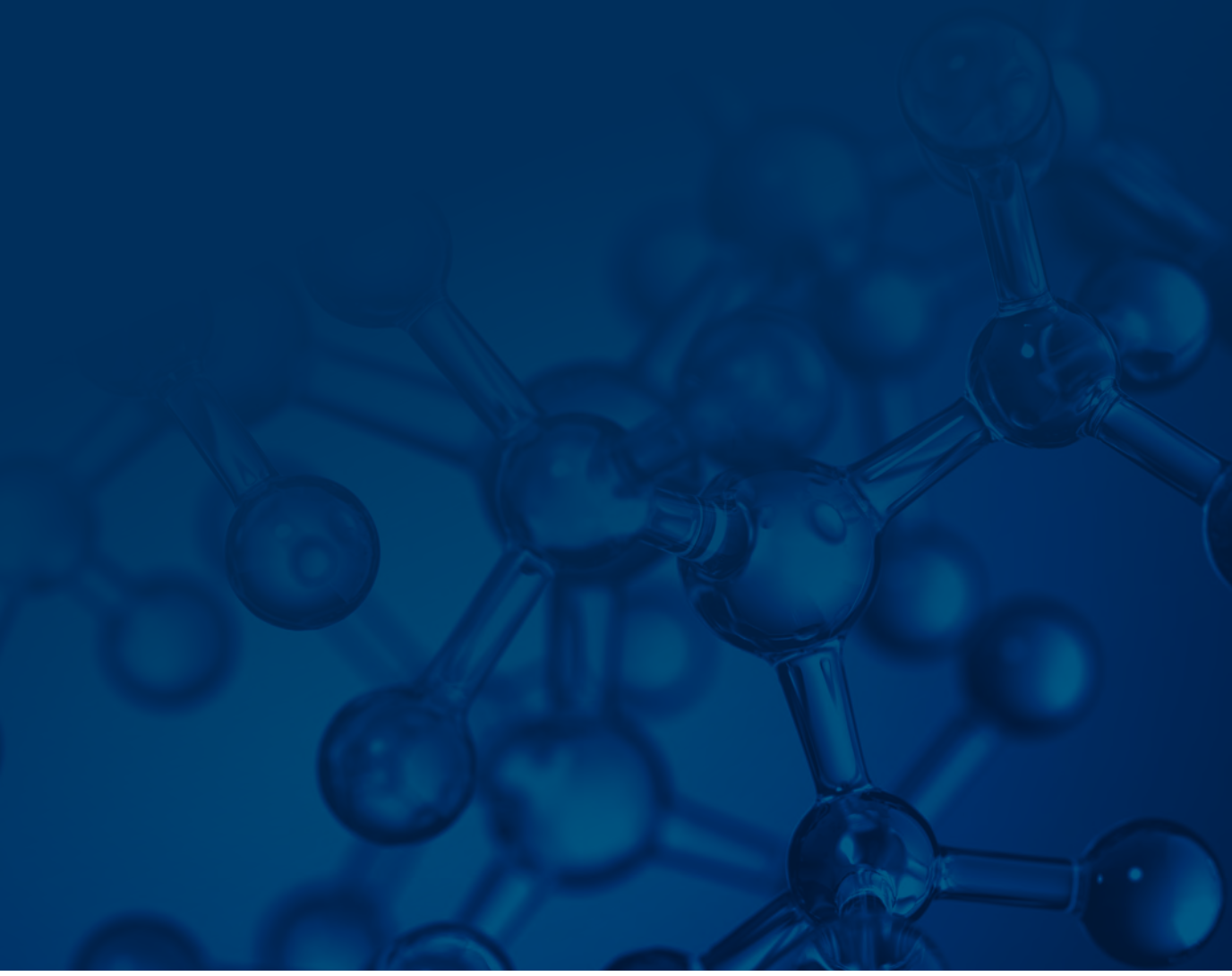
Naši partneri:
- Affri
- Bruker Alicona
- Comet Xray
- Eddyfi
- CGM NDT
- GNR Italy
- IBG
- Vericon
- Vigor
- BowmanXRF
- Uniterm
- Acer Industries

Industrije:
- Automobilska
- Elektronika
- Avio-industrija
- Strojna obrada
- Metalurgija
- Baterije
- Kemijska industrija
- Laboratoriji

Stručnost:
- Kemijska analiza
- Metrologija
- NDT Ispitivanja bez razaranja
- X-Ray tehnologije
- Računalni vid
- Ispitivanje materijala

Usluge:
- Instalacija
- Podrška
- Obuke
- Servis
- Mjerenja

http://www.emus.hr/



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