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BOOK OF ABSTRACTS

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Dear doctoral students,

It is a great honor and a special pleasure to welcome you to the seventh Symposium of doctoral students of the Faculty of Science. The number seven is already a big enough number that we can say that a kind of tradition of holding the Symposium is being created. The large number of registered doctoral students gives us the right to think that we are on the right track.

This time we have decided that all oral presentations as well as abstracts in the Proceedings will be in English. We believe that this increases the visibility of your research and allows your results to reach the wider scientific community. It should also be said that presentations in English help you as a preparation for the challenges that await you.

I will also allow myself one piece of advice that I must give at introductory lectures to students at the very beginning of their studies. Be curious! Ask! Ask everything!

I would like to thank the members of the Organizing Committee for their tireless and dedicated work. I would also like to thank my fellow professors from the Scientific Committee.

On behalf of the Scientific and Organizing Committee of the Symposium, I wish you successful and pleasant work at the Faculty of Science.

Professor Mladen Vuković
Vice-dean for teaching

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11:30-12:00	Invited Lecture 4 — Lecture Hall: A1 **Prof. Hrvoje Šikić** Stochastic model of eye lens growth

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Josipa Čonkaš
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Ratko Cvitanić
Distribution of the European flat oyster population in the beam trawl fishing area of the western coast of the Istria peninsula from 2013 till 2021 (P-B2)

Marija Fabijanec
Concentration and quality of RNA and microRNA isolated from formalin-fixed paraffin-embedded tissue samples of patients diagnosed with colorectal cancer or colorectal adenoma (P-B3)

Antonija Matek
Primary production in the Adriatic Sea – a review with emphasis on new data obtained at Lastovo Island (P-B4)

Matej Nemčić
Investigating the N-glycosylation of immunoglobulin A in type 1 diabetes (P-B5)

Dorotea Pali
Microevolution of a mumps based recombinant virus with HCV genes during passaging in vero cells (P-B6)

Ivana Pavičić
Effects of S-adenosylhomocysteine-hydrolase down-regulation on WNT signaling pathway in SW480 cells (P-B7)

Ena Šimunić
Sirtuin 3 protein in sex-specific maintenance of energy homeostasis during aging (P-B8)

Damira Veseljak
The satellitome of the confused flour beetle *Tribolium confusum*: genomic and cytogenetic aspects (P-B9)

Barbara Vuić
The potential protective role of dehydroepiandrosterone and its sulfate in the genetic and pharmacologically induced animal model of Alzheimer's disease (P-B10)

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Vedran Biondić Fučkar
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Tatiana Galicová
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Mia Gotovuša
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Lejsa Jakupović
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Noelia Lázaro
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Antonia Matić
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Ana Mikelić
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Marina Poljak
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Ivan Pucko
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Marcela Šišić
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Monika Šoltić
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Dalibor Tatar
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Ana Tolić
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Snježana Zubčić
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Lea Barbarić
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Lucija Markotić
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Dubravka Božić
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Nika Pasković
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Ljiljana Ivanković
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Rafaela Radičić
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Doris Brkić
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Andrea Čačković
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Emerik Galić
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Iva Jurčević
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Zoran Kiralj
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Marina Mašanović
Morphological characterization of Norway lobster *Nephrops norvegicus* (Linnaeus, 1758) populations in the Adriatic Sea (P-B17)

Karla Ostojić
Characterization of patient-derived sarcoma stem cells (P-B18)

Lea Ružanović
Party in the dry riverbed! How spiders use different intermittent river habitats (P-B19)

Paula Štancl
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Ana Tutić
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CHEMISTRY

Barbara Bogović
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Katarina Jerin
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Jelena Kovačić
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Martina Manenica
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Mario Pajić
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Petra Petrović
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Goran Pipalović
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Marin Popović
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Stjepan Šarić
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Lucija Vujević
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Laura Huljek
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Ana Rapljenović
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Nika Ugrin
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Toni Dunatov
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Emina Džaferović-Mašić
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Gaurav Pransu
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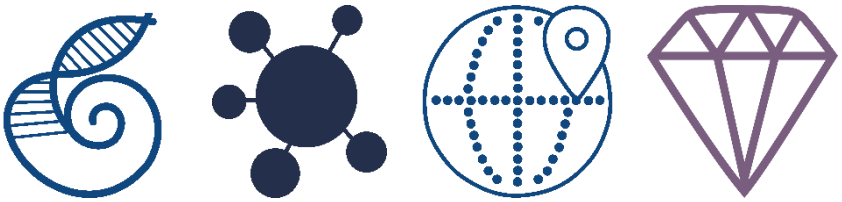

INVITED LECTURES

Dr. Ivana Brekalo

Dr. Ivana Brekalo was born in Split and completed her bachelor's and master's degree in chemistry at the Faculty of Science and Mathematics in Zagreb. After spending some time in Pliva, she went to North America for her doctorate, at Georgetown (Washington DC, USA) and McGill (Montreal, Canada) universities. There, she mainly studied porous materials and their preparation using mechanochemical methods. After her doctorate, Ivana returned to Croatia and started a position at the Ruđer Bošković Institute as a postdoctoral researcher in the Laboratory for Applied and Sustainable Chemistry, where she continues her work in developing new methods in mechanochemistry. She used her six-month stay at the University of Warsaw to learn advanced methods in computational chemistry, which she now wants to apply to support her experimental work. Ivana is the author of several scientific papers, she has presented her research at international scientific meetings, winning many awards, and she is particularly interested in scientific communication. In her free time, she dances, plays board games, loves to spend time in nature, and loves applying chemistry in the kitchen (cooking and baking).

BETTER LIVING AND CLEANER SCIENCE THROUGH MECHANOCHEMISTRY

Ivana Brekalo[1*]

[1]Postdoctoral researcher at the Laboratory for Applied and Sustainable Chemistry, Department of Physical Chemistry, Ruđer Bošković Institute
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The growing human population - over 8 billion of us at this point - requires an ever-increasing amount of resources (food, water, fuel...), while at the same time producing alarming amounts of waste, greenhouse gases, and environmental pollution. A sustainable way of acquiring the needed resources and ameliorating the produced waste is therefore crucial for the continued prosperity of the human race. Food production in particular largely depends on the manufacturing of artificial fertilizers, which are energy intensive to make and often create a lot of waste. Therefore, a better way of producing and using artificial fertilizers would go a long way towards a more sustainable future. Indeed, sustainable nitrogen cycle management was named as one of the 14 Grand Challenges for Engineering in the 21st century [1].

We decided to tackle the problem of sustainable fertilizers using urea as an example. Urea is one of the most common artificial nitrogen fertilizers, but decomposes readily under common agricultural conditions [2]. We used mechanochemistry to combine urea with gypsum, a common byproduct of the construction industry [3]. We thus obtain a stabilized fertilizer product that also provides key micronutrients (sulfur and calcium), and in addition can reuse

waste construction gypsum. Compared to a solution-based process, the mechanochemical synthesis is waste-free, more energy-efficient, and faster. We explore the effect of different forms of starting materials on the synthesis outcome, and performed scale-up of the synthesis, reaching a maximum yield of 330 g/h.

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[3] Brekalo, I.; Martinez, V.; Karadeniz, B.; Orešković, P.; Drapanauskaite, D.; Vriesema, H.; Stenekes, R.; Etter, M.; Dejanović, I.; Baltrusaitis, J.; Užarević, K. ACS Sustainable Chem. Eng. 2022, 10, 6743–6754.

Dr. Antica Čulina

Antica's expertise covers evidence synthesis, data and code standards, evolutionary ecology of bonding, and life-history trade offs. She is one of the pioneers in studying and promoting Open Science practices in ecological and evolutionary research. Much of her current work is dedicated to meta-research, an emerging multidisciplinary field that aims to detect and solve issues in the research ecosystem. Via meta-research and Open Science, she strives to help ecology to solve issues currently present in the research and publishing systems, increase diversity of researchers, and thus improve the scope, reach, and value of research.

Antica is a senior researcher at the Ruđer Bošković Institute, and a Honorary fellow at the Netherlands Institute of Ecology. She is a co-founder and executive committee member of SPI-Birds (www.spibirds.org) and SORTEE (https://www.sortee.org/). She is also on the advisory board of the FAIRsFAIR project (https://www.fairsfair.eu/advisory-board/egfc) and Open Knowledge maps (https://openknowledgemaps.org/team), and a member of UNESCO Open Science Initative.

DOING CREDIBLE SCIENCE – WHY WOULD YOU CARE?

Antica Čulina[1*]

[1]Senior research associate at Laboratory for Informatics and Environmental Modelling, Division for Marine and Environmental Research, Ruđer Bošković Institute
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Science is the systematic and objective study of the world: done according to a fixed plan, evidence-based, unbiased, and not dependent on cognitive biases. Thus, science should be credible by its definition. Yet, evidence shows that it is often not so. Across scientific fields studies are not replicable nor reproducible, published literature suffers from different biases including pre-publication bias (e.g. p-hacking) and publication bias. Response to this 'crisis' has been a slow but inevitable change to the new era of how we do science: in an open and transparent way.

In this talk, I will briefly overview the issues with the current research and reward system, and the challenges and benefits of transitioning to a new, open and more reliable system. I will further provide some tips on how to become a pioneer in a new era of science and what benefits you can get from open science. These range from the use of open data, application of integrative methods of evidence synthesis, registration of studies, and open software. While the examples in this lecture are mainly related to the field of Ecology, most of the principles are applicable to other areas of science.

Dr. Željka Fiket

Dr. Željka Fiket is a senior research associate and head of the Laboratory for Inorganic Environmental Geochemistry and Chemodynamics of Nanoparticles at the Division for Marine and Environmental Research of the Ruđer Bošković Institute. She holds a PhD in Oceanology from the University of Zagreb and was awarded by the L'Oréal-UNESCO for Women in Science. With her strong research interest in inorganic environmental geochemistry and a wide range of collaborations, she has had the opportunity to be (co-)author of more than 60 scientific papers and two book chapters, and to collaborate on or lead various projects. She is also a titular Assistant Professor in the Department of Geology in the Faculty of Science, where she teaches several courses, (co-)organiser of several Environmental Science Schools, and mentor of numerous graduate students, laboratory internships, and (currently only) 2 PhD students.

METALS - A FRESH TAKE ON A CLASSIC CONCEPT

Željka Fiket[1*]

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Metals are the backbone of modern civilization, indispensable for countless technological applications and crucial to many biological processes. But it is only through advanced technology that we have begun to fully understand their distribution and behavior, unlocking the potential for groundbreaking research in a variety of disciplines.

This talk will introduce the audience to the important role of metals in fields such as geochemistry, environmental chemistry, materials science, and health assessment. From deciphering sediment deposition and their fate in landfills to studying the uptake of nutrients in biota and mitigating the harmful effects of pollution, metals offer invaluable insights into some of the most pressing scientific questions of our time. Interdisciplinary research has also unearthed exciting new applications for metals, such as linking their presence in certain organs to disease incidence and even exploring the mechanisms of bacterial survival in space.

Overall, the study of metals is important for understanding a wide range of scientific phenomena, and as interdisciplinary research and new analytical techniques continue to advance, it is likely that the importance of metals in science will only continue to grow.

Prof. Hrvoje Šikić

Hrvoje Šikić (PhD, University of Florida 1993)**,** Professor of Mathematics, Faculty of Science, University of Zagreb. His research interests are in Probability Theory and Stochastic Processes, Harmonic Analysis, Math Applications in Biology and Economics. He was Marie Curie IOF Fellow 2014-17 (Washington University in St Louis). Visited over 20 Universities and Institutes, presented over 100 public lectures. Selected services: Vice president of the University Board, Head of the University Research Committee, Editor in chief of the oldest Croatian mathematics journal, Head of the Doctoral Program in Mathematics. Selected Prizes: Croatian Academy of Arts and Sciences Prize for 2009, Republic of Croatia Science Award for 2011, *Andrija Mohorovičić Award* for 2018, University of Florida Preeminence Award 2019. He is also a three-time recipient of the student award *Brdo* for best lecturers.

STOCHASTIC MODEL OF EYE LENS GROWTH

Hrvoje Šikić[1*]

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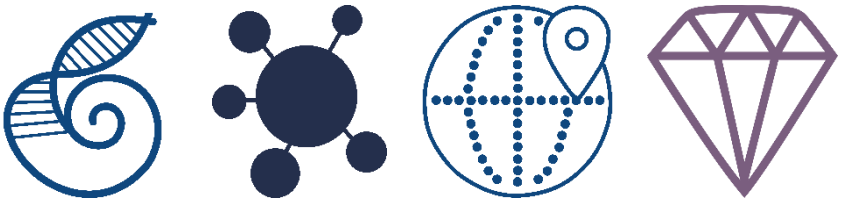
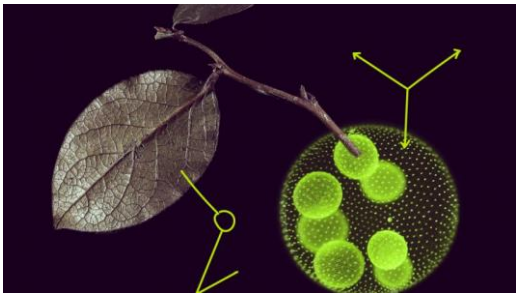
Biological lens in the eye of a mammal focuses light on the retina. Its shape and size is crucial for that purpose. We base our work on abundance of data collected at Washington University in St Louis, mostly on mice. We provide the first ever growth model of the mouse eye and succeed in capturing a variety of behavior about the size of the lens, number of cells in the anterior capsule of the lens (epithelium) and the dynamics of the cell movement between the various zones of the epithelium. Lens grows through the entire life and exhibits significantly different behavior throughout life. Our model is based on branching processes with immigration and emigration. (This is a joint work with Steven Bassnett and members of his lab at Washington University. Research supported by NIH grant R01 EYO9852 and a Marie Curie FP7-PEOPLE-2013-IOF-622890 MoLeGro Fellowship.)



WORKSHOPS



The Agency for Mobility and EU Programmes (AMEUP) is a public, non-profit organisation instituted by the Government of the Republic of Croatia in 2007 and acting within the system of the Ministry of Science and Education. Its mission is to support internationalization as a means of raising the quality in the sectors of science, education and training and the field of youth in the Republic of Croatia. As such, the Agency promotes the idea of mobility in education as a way to improve professional skills and knowledge, as well as to broaden personal horizons with the aim to create a knowledge-based society and to strengthen the competitiveness of Croatian citizens in the European labour market. Thus, the Agency's main task is to implement the three largest European Community programmes in the field of education, training, youth and sports – Erasmus+, the programme Horizon Europe in the field of research and development, and the European Solidarity Corps programme in the field of youth and volunteering.

Ivan Makovec has been working for AMEUP since January 2019 as a Senior Adviser in the Department for Horizontal areas of EU Framework Programmes and mobility of researchers. He is also a national contact point (NCP) for Marie Skłodowska-Curie Actions (MSCA) and Joint Research Centre (JRC) in Horizon Europe. As a part of the project team in AMEUP, he has been involved in various projects related to the mobility and career development of the researchers, as well as MSCA NCP´s network projects. He graduated from the Faculty of Humanities and Social Sciences with a master’s degree in Sociology and History.

WHAT AFTER THE PHD - POSTDOCTORAL FELLOWSHIPS IN THE MSCA PROGRAM?

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Marie Skłodowska-Curie Actions, as a part of Horizon Europe, are the European Union´s flagship funding programme for doctoral education and postdoctoral training. MSCA programme fund excellent research and innovation and equip researchers at all stages of their career with new knowledge and skills, through mobility across borders and exposure to different sectors and disciplines. The MSCA help build Europe's capacity for research and innovation by investing in the long-term careers of excellent researchers.

Postdoctoral Fellowships action targets researchers holding a PhD who wish to carry out their research activities abroad, acquire new skills and develop their careers. Postdoctoral Fellowships help researchers gain experience in other countries, disciplines and non-academic sectors. In this presentation, you will find out more about this prestigious EU programme: types of MSCA PFs, who can apply for PF, what the funding covers and how to apply. In addition, the presentation will tackle the possibilities for doctoral students and postdocs within the EURAXESS initiative.

Dr. Ivan Biočić

Ivan Biočić is a mathematician born in 1993, in Zagreb. He spent his youth in Brckovljani, graduated from Gymnasium Sesvete, and secondary music school Elly Bašić in the class of Prof. Ante Čagalj, both in Zagreb. In 2015 he got his Bachelor's degree in mathematics, and in 2017 he got his Master's degree in mathematical statistics, both at the Faculty of Science in Zagreb. During this period, he received scholarships from the Rotary Club Sesvete, the Republic of Croatia, and the Adris Foundation, as well as rewards for best students and extraordinary success at the Faculty. In 2014 he attended the Modern Mathematics Summer School for Students in Lyon where he shook hands with J.H. Conway, thus becoming five handshakes away from J.C.F. Gauss (Gauss-Dedekind-Cantor-Russell-Conway).

From 2018 he works as a research and teaching assistant at the University of Zagreb, Faculty of Science, Department of Mathematics, where in 2022 he finished his PhD summa cum laude under the supervision of Prof. Zoran Vondraček with the topic Semilinear equations for non-local operators. During his doctoral studies, he visited many summer schools, workshops, and conferences. Among others, he gave a talk at the workshop Deterministic and stochastic fractional differential equations and jump processes at Isaac Newton Institute, Cambridge, UK. His scientific work resulted in three published articles thus far, two of which are solely authored.

In his free time, he enjoys spending time with his two little kids, playing sports – swimming, water polo, chess, and "Prvi karlovački desetoboj", reading, and avoiding social media.

(MIS)USE OF STATISTICS: IN SCIENCE AND BEYOND

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In the workshop, students and the lecturer will discuss the ways in which statistics can be manipulated or misinterpreted in both scientific and non-scientific contexts. Common errors or biases that can arise when working with data will be highlighted. This includes cherry-picking results, using inappropriate statistical tests, failing to account for confounding variables, p-value hunting, etc. In the lecture examples of how statistics can be used to mislead or manipulate people will be provided, e.g. in advertising or political campaigns. Overall, the lecture will emphasize the importance of using statistics accurately and responsibly, and the importance of being aware of the potential pitfalls and limitations of statistical analyses.

Dr. Mateo Kruljac

Mateo Kruljac was born in Zagreb, Croatia in 1995. In 2013 he graduated from "I. gimnazija" high school in Zagreb and enrolled at the Faculty of Science in Zagreb in an integrated undergraduate and graduate study of research Physics. During his student days, he was an active participant in Open Door Days of the Faculty, a member of student organizations and a student representative. He graduated in 2018 with a master's degree in Physics. From September 2018 to December 2022, he was employed at the Institute of Physics as a research assistant where he did his PhD research. He was a teaching assistant at the Faculty of Science for experimental courses. His area of expertise includes experimental work with lasers, optics, atomic physics and cold atoms, alkali vapor spectroscopy, optical resonators and frequency combs. He is currently employed as a postdoc at the Institute of Physics in Zagreb. He actively participated in popular science events, including lab tours, visits, public events and TV programs.

WRITING AS A SCIENTIST AND THE MISTAKES WE MAKE

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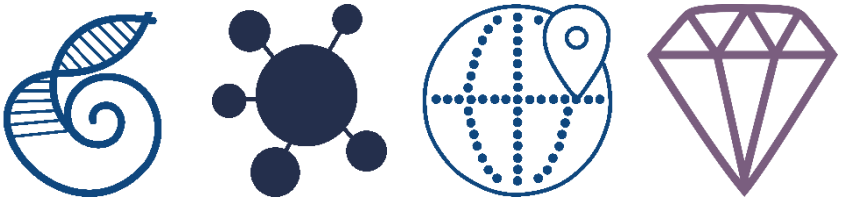
Communicating scientific ideas in a written form is a big part of every scientist's life. Whether it's lab reports, journal papers, emails or proposals, we need to convey complex points and ideas to an audience that has more or less (or none at all) knowledge of our work. It is not uncommon to find texts that lack clarity and lose focus on the main points even in papers intended for a well-informed audience within the field. Scientific writing is a skill that every student needs to learn during their PhD and keep training throughout their career. Even though different people prefer different writing styles, in this workshop I will present some common tips to help with the writing process, like understanding the audience and the style suited best for that audience. I will also discuss the most common mistakes we make and how to fix them or even avoid them completely. The topics of this workshop are based on a well-established book "The Craft of Scientific Writing" by Michael Alley.



ORAL PRESENTATIONS

EVALUATING PHOTOSYNTHETIC PERFORMANCE AND PHOTOPROTECTIVE POTENTIAL OF THE TROL-FNR BIFURCATION

Ena Dumančić[1*], Hrvoje Fulgosi[1]

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Photosynthesis is the process in photoautotrophic organisms that converts light energy into chemical energy [4]. The very important part of this process is the transfer of electrons from reduced ferredoxin to nicotinamide adenine dinucleotide phosphate ($NADP^+$), which is catalyzed by the flavoenzyme Ferredoxin-$NADP^+$ oxidoreductase (FNR) [2]. Binding of the FNR to photosynthetic membranes in many vascular plants is assisted by the thylakoid rhodanese like protein (TROL) [1]. Within my PhD project, I am studying the influences of the TROL-FNR protein complexes on electron transport pathways and reactive oxygen species (ROS) scavenging, which suggest the protective role of this complexes, and the management and the distribution of high energy electrons in energetic processes of photosynthesis [3]. My aim is to determine the influence of soil humidity and abiotic stress conditions, in this case drought, as well as the deficiency of certain elements of this complex on the functions of the TROL-FNR pair. The experiments are carried out on *Arabidopsis thaliana* (L.) Heynh. as a model plant, wild type and mutant lines (ΔITEP, ΔPEPE, Δρ, TROL KO, D207E, D207N) cultivated in our laboratory under controlled conditions. So far, I have carried out experiments and obtained preliminary results which includes photographic and/or graphical representation for quantitative Western blot analysis of the RuBisCO enzyme, spectrophotometrical measurements of the pigments content (chlorophyll a, b, carotenoids), ROS ($^1O_2$, H_2O_2, O_2^-) detection with fluorescent probes by using confocal laser scanning microscope, and leaf architecture studies by using invert light microscope, also serving as the preliminary experiments for the transmission electron microscopy (TEM). The results indicates that different growth conditions and mutations have influence on amount of RuBisCO, ROS, pigments, activity of antioxidant enzymes and leaf architecture. My research will contribute to the understanding of the behavior of plants under severe stress conditions, especially important in the times of global warming.

ACKNOWLEDGMENTS

This research is funded by the Croatian Science Foundation (HRZZ) Grants: IP-2020-02-8590 and DOK-2021-02-2018 to HF.

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DO BROCCOLI'S PHENOLICS LIKE IT HOT OR COLD?

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Plants produce specialized metabolites, phenolics being one of them, in order to adapt to abiotic and biotic stresses more successfully [1]. This study aimed to investigate which groups of phenolics in broccoli seedlings (*Brassica oleracea botrytis* var. *cymosa*) are more susceptible to concentration changes at high and low growing temperature. To answer this, in the fall of 2022/2023, we cultivated three biological replicas of broccoli seedlings in three different temperature conditions: high (38 °C day/33 °C night), low (12 °C day/7 °C night), and regular (23 °C day/18 °C night) as a control group. Seedlings were lyophilized, extracts in 70% ethanol prepared and spectrophotometric analyses of total phenolics [2], flavonoids [3], flavonols [4], hydroxycinnamic [4] and phenolic acids [5] were conducted. According to the results, total flavonols and flavonoids decreased significantly when seedlings were grown at both high and low temperatures, while total phenolics, phenolic and hydroxycinnamic acids decreased significantly only when grown at high temperature. Out of these groups of phenolics, total flavonols were the most susceptible to change when grown at high temperature, while total flavonoids were the most susceptible to change when grown at low temperature. Total phenolic acids were the most resistant at high and low temperature cultivation. In conclusion, high temperature cultivation significantly reduced the concentration of all analyzed groups of phenolics and had more impact on phenolics of broccoli seedlings than low temperature cultivation.

ACKNOWLEDGEMENTS

This study was conducted in scope of the Croatian Science Foundation research project IP-2020-02-7585 "Indirect Effect of Global Warming on Mammals Physiological Parameters via High-Temperature Stressed Plant Diet (TEMPHYS)".

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DIVERSITY OF ANTS (INSECTA: HYMENOPTERA: FORMICIDAE) IN OLIVE GROVES AND VINEYARDS IN ZADAR COUNTY (CROATIA) WITH NOTES ON DNA BARCODING AND CONSERVATION BIOLOGY

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Faunal research on ants in the Mediterranean area of Croatia, especially in agricultural systems, is very rare [1]. Since the Mediterranean area has high species richness, and the way of management in agriculture can further affect the diversity of species, the ant fauna in olive groves and vineyards in the Zadar County was investigated [2,3]. Diversity indices were compared between areas with different management modes; in olive and vineyard crops with integrated and ecologically based plant managements in which different groups of pesticides are used, and in a natural habitat without management, where there was no use of pesticides. Ants were sampled during the 2018 growing season by using beating branch method, Tullgren funnels, and pitfall traps. Species were identified morphologically and by DNA barcoding, compiling the final list of 14 ant species. All sequences of determined ant species were present at the National Biotechnology Information Center (NCBI) database. Sampling methods influenced the composition and abundance of species. According to the collected data, olive groves with integrated plant management, compared to organic olive groves, had less diversity. Therefore, the impact of different management practices in olive groves on ant biodiversity could be investigated in more detail by studying ant communities on a larger number of plots.

ACKNOWLEDGMENTS

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DIVERSITY OF EBNA-1 AND EBNA-2 IN EPSTEIN-BARR VIRUS-ASSOCIATED INFECTIOUS MONONUCLEOSIS

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Epstein-Barr virus (EBV) belongs to the *Herpesviridae* family, genus *Lymphocryptovirus*. It infects around 95% of people worldwide and is associated with malignant (including Burkitt's lymphoma, Hodgkin's lymphoma, nasopharyngeal cancer and lymphoproliferative diseases) as well as non-malignant diseases including infectious mononucleosis. After initial infection, EBV persists in host cells, mainly B-lymphocytes, in the form of episome [1]. The EBV nuclear antigen 1 (EBNA-1) protein is necessary for the replication of EBV during the latent phase. EBNA-1 binds to both viral and host chromosomal sites through its C-terminal domain (aa 459-607). Based on the *EBNA-1* , the virus is classified into different prototype variants (P-ala and P-thr) and associated subvariants (P-ala', P-thr' and P-thr'') [2]. Besides EBNA-1, at the molecular level, virus can be classified into two types (EBV type 1 and EBV type 2) which differ according to mutations in the EBV nuclear antigen 2 (*EBNA-2*) gene. EBV type 1 contains the 497 bp EBNA-2 protein while EBV type 2 contains 150 bp EBNA-2 protein [3]. Different size of EBNA-2 protein is considered one of the possible causes of the difference in cellular tropism between the two types of EBV [4]. The aim of this study was to analyse *EBNA-1* variant and subvariant diversity as well as *EBNA-2* in 24 pediatric patients with infectious mononucleosis (IM). *EBNA-2* gene and C-terminal region of *EBNA-1* were analysed by Sanger sequencing using customised primers designed in PrimerBlast. Obtained sequences were compared with a reference sequence (EBV strain B95-8) and analysed with bioinformatics alignment tools (SnapGene 3.5.2. and Mega Software). All of the obtained sequences gave 497 bp EBNA-2 gene so they were classified as EBV type 1. Regarding *EBNA-1* variants, 5/24 sequences were classified as P-ala and 19/24 sequences as P-thr. In total, 5/24 sequences were P-ala' subvariant, 13/24 P-thr' and 2/24 P-thr'', 4/24 sequences could not be classified into defined subvariants. These results point to the uniformity of EBV types in Croatia and the diversity of *EBNA-1* subvariants in IM. Further research, regarding more sequences, is needed to get an adequate overview of the prevalence of EBV *EBNA-1* subvariants in pediatric patients with IM.

ACKNOWLEDGMENTS

This study was supported by a grant from the Croatian Science Foundation titled "Molecular diversity of Epstein-Barr virus" (grant number IP-2020-02-8961, principal investigator Snjezana Zidovec Lepej).

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METAL HYPERACCUMULATING PARASITES EXPOSED TO CADMIUM: EFFECTS ON GENE EXPRESSION

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In recent years, parasites are increasingly used as bioindicators of environmental quality [1]. Acanthocephala, also known as thorny-headed worms, are proving to be particularly sensitive indicators of metal pollution in ecotoxicological studies of aquatic ecosystems. They are obligate endoparasites that in the adult stage live in the intestines of vertebrates and take up nutrients from the intestinal lumen of their host. Acanthocephalans can absorb toxic metals more efficiently than other commonly used aquatic bioindicators, such as fish, crustaceans, and bivalves [2]. However, the mechanism of metal homeostasis and accumulation in acanthocephalans is still unexplained. Therefore, we investigated the effects of *in vitro* Cd^{2+} exposure on metal accumulation and gene expression in *Dentitruncus truttae* Sinzar, 1955, hosted in brown trout (*Salmo trutta* Linnaeus, 1758) from the Krka River. Parasites were exposed to 2 and 10 mg Cd^{2+} l^{-1} in culture for 3 and 5 days, and Cd^{2+} levels in the organisms were determined using HR ICP-MS. Next-generation RNA-Seq technology was used to investigate genome-wide differentially expressed gene profiles between control and Cd^{2+}-treated acanthocephalan specimens. Our study confirmed the ability of these parasites to accumulate high metal concentrations. When exposed to 10 mg Cd^{2+} l^{-1}, they accumulated 188.6 mg Cd^{2+} g^{-1} after three days and 267 mg Cd^{2+} g^{-1} after five days. Exposure to these high concentrations resulted in significantly different gene expression compared to the control. At a Cd^{2+} dose of 2 mg l^{-1}, a total of 4826 differentially expressed genes (DEGs) were detected (predominantly down-regulated), whereas at a dose of 10 mg l^{-1}, 5809 DEGs were detected (predominantly up-regulated). The most enriched biological processes included: protein digestion and absorption, gap junction, focal adhesion, apoptosis, and genes related to infection and disease. Understanding the process by which acanthocephalans accumulate metals could be important in assessing environmental metal exposure and explaining the response of the infected vertebrate host, so Environmental Parasitology represents an important novel research field.

ACKNOWLEDGMENTS

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EVOLUTIONARY PATTERNS IN THE BIOFILM OF PATHOGENIC *Escherichia coli*

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Uropathogenic *Escherichia coli* (UPEC) are highly versatile pathogens, that colonise the gastrointestinal tract as commensals and can cause disease in the urinary tract as opportunists [1]. *E. coli* UTI89 is one of the most common uropathogenic strains, causing 85% of all urinary tract infections (UTIs) [2]. UTI89 undergoes a complicated pathogenic pathway with extracellular and intracellular lifestyles, that include biofilm-like bacterial communities. The ability of UPEC strains to form a biofilm appears to be important for their pathogenicity and recurrence of UTIs in patients, as 50% of clinical isolates form biofilms [2]. Macrocolony biofilms display a high degree of spatiotemporal organisation and are therefore a valuable model for studying ontogeny-phylogeny correlation [3]. Total RNA was extracted from liquid-culture (LC) and *E. coli* UTI89 biofilms grown for 6H, 12H (hours), 1D, 1.5D, 2D, 3D, 5D, 7D, 14D, 21D (days), and 1M (month). We sequenced the RNA samples to obtain whole transcriptomes. PCA analysis of the transcriptomes explains 76% of the variation in expression profiles and reveals temporally discrete stages during biofilm maturation (Fig. 1a). Transition stages of biofilm growth are also distinguishable in all-against-all comparison using Pearson correlation (Fig. 1b). After establishing *E. coli* UTI89 biofilm growth as a temporally organised process, we will study the evolutionary imprints to explore the adaptation and pathogenesis of *E. coli* UTI89 during biofilm maturation [3].

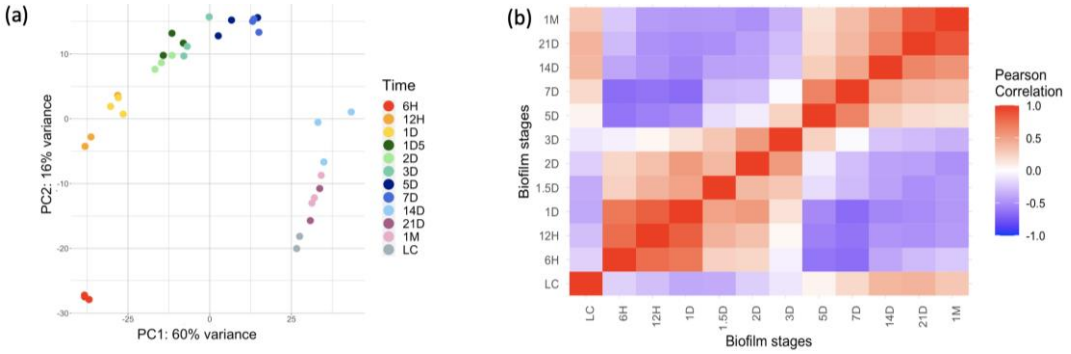

Figure 1. (a) PCA shows temporal organization of biofilm growth. (b) Pearson's correlation coefficients in all-against-all comparison between chosen time-points.

ACKNOWLEDGMENTS

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MORPHOLOGICAL AND DNA METABARCODING ANALYSIS OF THE STOMACH CONTENTS OF ATLANTIC BLUEFIN TUNA (*Thunnus thynnus* Linnaeus, 1758) IN THE ADRIATIC SEA

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Atlantic bluefin tuna (BFT), *Thunnus thynnus* Linnaeus, 1758, is among the most important marine predators and is an important target species for commercial and recreational fisheries. BFT is also important for aquaculture in Croatia, where 85% of the commercial catch is destined for aquaculture. Here, we analysed the stomachs of 24 BFT (including juvenile and adult individuals of approximately 8 to 80 kg) collected in the eastern Adriatic Sea using morphological inventory and DNA metabarcoding. DNA metabarcoding was preliminary tested on five individuals. DNA was obtained with a commercially available kit by extracting DNA from a stomach swab and a homogenate of stomach contents. Universal primers for metazoans were applied for amplification of partial fragments from two gene regions (cytochrome c oxidase subunit I and the ribosomal 18S-V1V2 region) [1] and commercially sequenced using the Illumina Miseq platform. Prey identification using the molecular DNA metabarcoding approach yielded a greater diversity of prey than using the morphological approach. We also noted a large difference in sequencing reads between the two types of DNA samples, with most reads in the case of the stomach swab coming from tuna DNA, i.e. from the host. The most abundant prey species were sardine (*Sardina pilchardus*, ≈51%), anchovy (*Engraulis encrasicolus*, ≈20%), Mediterranean horse mackerel (*Trachurus mediterraneus*, ≈17%), mackerel (*Scomber colias*, ≈9%), and cephalopods (≈3%). It is noteworthy that some demersal and gelatinous species were detected as prey, such as Atlantic stargazer (*Uranoscopus scaber*), European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), small-spotted catshark (*Scyliorhinus canicula*) and *Salpa* spp. These results suggest that ABT is an opportunistic forager and that DNA metabarcoding approach enables more accurate prey identification and provides greater prey diversity in comparison to the morphological approach. Therefore, DNA metabarcoding can be used as a powerful tool for analysing the stomach contents of important marine predators, but unlike the morphological approach, it is limited in quantifying prey species, so these two methods should be used side by side to complement each other.

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INFLUENCE OF Pt/SnO_2 SYNTHESIS PROCEDURES ON THE CATALYTIC REDUCTION OF 4-NITROPHENOL TO 4-AMINOPHENOL

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In this work, we performed a one-step microwave-assisted hydrothermal synthesis for the dispersion of platinum (Pt) on a reducible SnO_2 support. Tin tetrachloride and hexachloroplatinic acid dissolved in water were used as starting chemicals. The syntheses were carried out with and without the addition of ammonia. The molar ratios of tin and platinum ($[Pt^{IV}/(Sn^{IV} + Pt^{IV})]$) were varied between 0 and 0.15. The XRD results of the Pt/SnO_2 sample synthesized in the presence of ammonia and 5 mol% Pt showed five crystalline phases: Cassiterite (SnO_2), NH_4Cl, $(NH_4)_2PtCl_4$, $(NH_4)_2PtCl_6$ and $(NH_4)_2SnCl_6$. The STEM image (Figure 1. A) shows that the small platinum nanoparticles are well dispersed on the SnO_2 support. The synthesized samples were used for the catalytic reduction of 4-nitrophenol (4-NP) to 4-aminophenol (4-AP) in the presence of excess $NaBH_4$. The catalytic activity of the Pt/SnO_2 samples for the reduction of 4-NP to 4-AP was optimized by varying the synthesis parameters and Pt loading [1]. Figure 1. B shows the catalytic reduction of 4-NP to 4-AP in the presence of excess $NaBH_4$ as a function of time using Pt/SnO_2 sample containing 5 mol% Pt synthesized in the presence of ammonia.

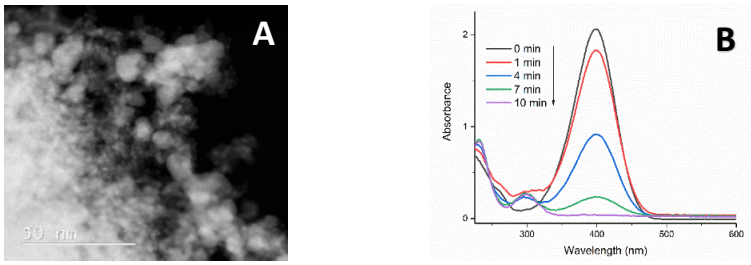

Figure 1. STEM micrograph of Pt/SnO_2 samples with 15 mol% Pt, A, and catalytic reduction of 4-NP to 4-AP as a function of time using Pt/SnO_2 sample with 5 mol% Pt and synthesized in the presence of ammonia, B.

ACKNOWLEDGMENTS

This work was financially supported by Croatian Science Foundation under the project IP-2019-04-1195 "Platinum decorated iron tin oxide solid solutions for hydrogen gas sensing" (HydGasSens) and by Croatian Government and the European Union through the European Regional Development Fund - the Competitiveness and Cohesion Operational Programme (KK.01.1.1.01.0001).

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WATER-SOLUBLE COMPOUNDS IN $PM_{2.5}$ IN URBAN ATMOSPHERE

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Air pollution with respect to elevated levels of ambient particulate matter (PM) presents a major scientific concern, as numerous studies have indicated its adverse effect on human health and the environment. Ambient PM is a mixture of solid, liquid, and gas phase particles suspended in the air that varies in size, shape, chemical composition, concentrations, and origin. PM can be either directly emitted into the atmosphere from primary sources (vehicular exhausts, fossil fuel combustion, biomass burning, dust resuspension, sea-spray, volcanic eruptions) or can be produced as secondary particles through photochemical transformation or gas-to-particle conversion from volatile organic compounds (VOC) with anthropogenic and/or natural origin [1]. Owing to its size, PM is classified into different fractions among which the fine-particulate matter fraction ($PM_{2.5}$) has the greatest impact on human health because it penetrates deep into the human lungs. A significant proportion of $PM_{2.5}$ particulate matter mass consists of elemental carbon (EC), water-soluble ions (SO_4^{2-}, NO_3^-, NH_4^+) and organic matter (OM) with water-soluble organic acids (OA) as a fraction of organic carbon (OC). In comparison with other compounds, OA constitutes a smaller part of $PM_{2.5}$ particulate matter mass, but its determination is significant since it can change particulate properties and, along with other compounds, be considered as a marker to identify possible air pollution sources as well as their type, intensity and/or temporal and spatial distribution [2–4]. The aim of this study was to investigate the mass concentrations of water-soluble anions (Cl^-, NO_3^-, SO_4^{2-}) and cations (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}), as well as OA (CH_3COO^-, $HCOO^-$, $C_2O_4^{2-}$), in $PM_{2.5}$ and their ratios in order to determine the present sources of air pollution. Also, these are the first continuous measurements of water-soluble organic acids in $PM_{2.5}$ content collected during winter at three urban measuring sites in Zagreb. The results of this study indicate the presence of different primary (mobile, stationary) and secondary sources. Future research will be focused on examining the temporal and spatial distribution in order to obtain a better characterization of present sources and their contribution to the overall air pollution in Zagreb.

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CHARACTERIZATION OF MANDARIN PEEL PECTINS AND APPLICATION IN THE GREEN SYNTHESIS OF SELENIUM NANOPARTICLES

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The valorization of agricultural and food waste as a source of bioactive compounds is an important aspect of a circular and sustainable bioeconomy, providing economic, social, and environmental benefits. In this work, pectin was extracted from mandarin peel using conventional hot acid extraction [1] with two final products – raw and purified pectin. Titrimetric methods were used for the characterization of extracted pectins [2]. The purification process resulted in a significant increase in equivalent mass (from 780 g/mol to 2018.8 g/mol), methoxyl content (from 9.1 % to 10.6 %) and degree of esterification (from 69.1 % to 86.6 %). The content of galacturonic acid was satisfactory (74.8 % in raw and 69.2 % in purified pectin) and shows that these pectins could be used as food additives, or for pharmaceutical purposes. Obtained pectin fractions were used as stabilizing agents for the green synthesis of selenium nanoparticles (SeNPs). After dialysis, formulations were stored for 30 days at 4 °C, and zeta potential and particle size distribution were measured at different time points. Average hydrodynamic diameter decreased during storage, while zeta potential values remained relatively unchanged. The most notable decrease occurred in SeNPs stabilized with raw pectin (84.7 nm decrease in size). The use of purified pectin fractions as stabilizers resulted in smaller average diameters (< 200 nm) and improved stability, compared to SeNPs stabilized with raw pectin fractions. To conclude, mandarin peel is a valuable source of pectin which can be used for the creation of different nanoceuticals.

ACKNOWLEDGMENTS

This work was supported by the Croatian Science Foundation [grant number HRZZ-IP-2018-01-8119] and project FarmInova (KK.01.1.1.02.0021) funded by the European Regional Development Fund. The work of doctoral students Emerik Galić and Nikolina Golub was fully supported by the "Young researchers' career development project—training of doctoral students" of the Croatian Science Foundation through grants HRZZ-DOK-2018-09-1298 and HRZZ-DOK-2021-02-6801.

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SYNTHESIS AND APPLICATION PROPERTIES OF FATTY ACID HEXYL ESTERS AND THEIR BLENDS WITH MINERAL DIESEL

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Biodiesel is a renewable fuel that consists of fatty acid monoalkyl esters, obtained via transesterification of vegetable oils or animal fats with an alcohol (usually methanol or ethanol), in a presence of a homogeneous or heterogeneous alkaline or acidic catalyst. Molecular weight of the alkyl moiety in the ester structure can have an influence on biodiesel's application properties. The increase in the alcohol chain length leads to an increase in e.g. biodiesel's density, viscosity and cetane number [1]. Density and viscosity are important in regards to the atomization of the fuel in diesel engine, whereas higher cetane number lowers ignition delay and leads to better combustion [2]. Fatty acid hexyl esters (FAHE) were synthesized at 60 °C, after an hour, from 1-hexanol and waste cooking oil (molar ratio of 12:1), in the presence of 1 wt% of potassium hydroxide catalyst. After purification, they were blended into binary (up to 20 vol%) and trinary blends (up to 15 vol%) with mineral diesel and/or 1-hexanol. Density, viscosity and low-temperature properties (cloud point, CP, and pour point, PP) were measured according to the standardized tests. Results showed that the addition of FAHE into the blends results in the increase in blends' densities and viscosities, while the influence on CP and PP is minor to none.

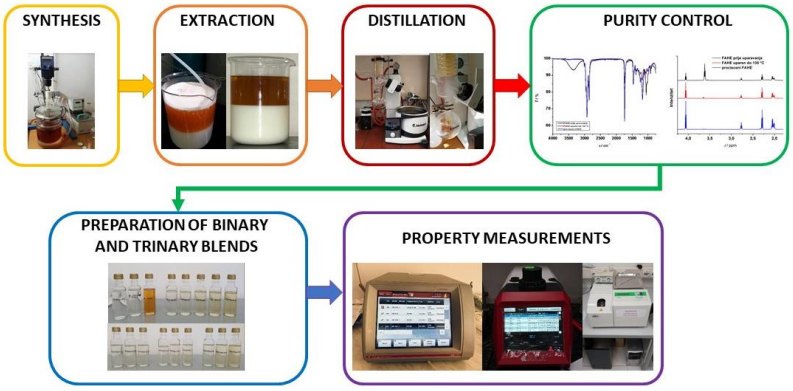

Figure 1. Synthesis, purification, and analysis of FAHE.

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DEVELOPMENT OF AN OPTIMIZED SAMPLE PREPARATION PROCEDURE FOR THE DETERMINATION OF TRACE LEVELS OF PHARMACEUTICALS IN FISH

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In the last few decades, pharmaceuticals (PhACs) have become one of the most prominent groups of emerging environmental contaminants. Since significant levels of PhACs are frequently reported in the aquatic environment [1,2], exposure of aquatic organisms to these highly biologically active substances might lead to bioaccumulation and adverse effects on non-target species [3]. Unfortunately, the current knowledge on the occurrence and fate of PhACs in aquatic biota is still rather scarce, primarily due to a lack of adequate analytical methods. The main challenges in the trace analysis of PhACs include the large number and physicochemical diversity of PhACs and the complexity of biotic matrices, which often require time-demanding and tedious sample preparation protocols [4].

In this work, a new multiresidue method for the determination of 44 PhACs and their metabolites in freshwater fish was developed. The emphasis was on the development of a robust and reliable sample preparation protocol, applicable to different lipid-rich fish tissue matrices. Various extraction solvents and cleanup techniques were examined in model experiments to optimize the key analytical parameters: analytical recovery, matrix effect, and reproducibility. The final method protocol involved ultrasound-assisted extraction of cryomilled muscle tissue with basified methanol in two cycles, followed by a three-step extract cleanup procedure, including cryoprecipitation, filtration, and solid-phase extraction. The analysis of final extracts was performed using an optimized multiresidue LC/MS-MS method which included separation of the target analytes on a Synergy Polar HPLC column and highly specific MRM detection. The quantitative determination was based on isotopically-labeled surrogates, which were added to the sample before the extraction. The developed method was applied to assess PhACs levels in feral freshwater fish from the Sava River.

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MECHANOCHEMICAL INTERZEOLITE CONVERSION OF FAU TO CHA ZEOLITE

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Zeolites are a class of microporous materials comprised of TO_4 tetrahedra with well-defined channels and cavities inside their supramolecular networks. This characterizes their porosity and stability, thus it is to no surprise that zeolites are widely used as catalysts, ion-exchangers and adsorbents. Chabazite (CHA) is a small pore zeolite comprised of a *cha* cage and a double 6-membered ring. It is most commonly used in gas separation [1] and selective catalytic reduction reactions [2]. Synthesis of CHA zeolite is usually carried out hydrothermally and addition of organic structure directing agents (OSDAs) such as *N*, *N*, *N*-trimethyladamantammonium iodide and/or seeds is not uncommon [3,4].
In an attempt to further expand our knowledge on zeolite synthesis *via* mechanochemical means which we have recently reported [5], we once again employed thermally controllable mechanochemistry [6] to synthetize CHA-type materials. Whereas the initial interzeolite conversion reaction resulted in a mixture of products (usually MER- and CHA-type materials), addition of water, alkaline cations and CHA seeds (prepared hydrothermally) to the reaction mixture was done in an attempt to obtain the pure CHA product. The desired product formed more readily when CHA seeds were used, as was proved by *in situ* PXRD measurements. Furthermore, higher water content in the reaction mixture appears to have slowed down the reaction so the intermediate mixtures of both the starting FAU and the product were present after 60 minutes, which was not the case in the other reactions. In summation, we have shown that usage of additional reactants and/or seeds plays significant role in mechanochemical interzeolite conversion and as such can be used as fast and selective synthesis method.

ACKNOWLEDGMENTS

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THE OP WARS - A NEW HOPE: EFFECTIVENESS OF NOVEL OXIME ANTIDOTES IN ORGANOPHOSPHATE POISONING

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Organophosphorus (OP) compounds were developed in Germany in the 1930s as pesticides and as warfare nerve agents (NA) since they were found to have a lethal effect on insects and mammals. Although 193 states signed the Chemical Weapons Convention in the 1997, which prohibits the production and use of NA, and they are slowly being replaced as pesticides by newer less hazardous formulations, OP compounds still pose a threat in terrorist attacks and they account for more than three million accidental or deliberate cases of poisoning a year worldwide [1]. OP exert their toxic effect primarily by inhibiting acetylcholinesterase (AChE), an essential enzyme for neurotransmitter acetylcholine (ACh) hydrolysis, and related enzyme butyrylcholinesterase (BChE). AChE inhibition leads to accumulation of ACh in the nerve system and overstimulation of cholinergic receptors in the entire body, which induces symptoms like nausea, convulsions, loss of consciousness, respiratory failure and ultimately death, while poisoning survivors additionally suffer from considerable irreversible neurological complications [2]. Emergency treatment of acute OP poisoning aims to recover the activity of the inhibited enzyme by pyridinium oxime reactivators that displace the phosphorus moiety bound within the enzyme catalytic site. Their disadvantages are that they generally weakly reactivate BChE, do not reactivate AChE in the brain due to their positive charge and the subsequent inability to cross the blood-brain barrier, and they are not universal reactivators of all NA and pesticides [3]. The goal of our study is to identify and kinetically characterize novel oxime antidotes which would efficiently reactivate BChE and potentially establish a pseudocatalytic scavenger system which could detoxify OP in the bloodstream before they reach target tissues [3]. Structurally various novel oximes were tested as reactivators of NA sarin-, cyclosarin-, VX- and tabun-inhibited human AChE and BChE, as well as chosen OP pesticides. For several oximes BChE reactivation potency was showed to be superior when compared to the standard oximes used in medical practice, and binding affinities of phosphylated BChE for some oximes increased up to 1900-fold compared to pyridinium oximes, establishing them as promising candidates for future treatment development.

ACKNOWLEDGMENTS

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MECHANOCHEMICAL ROUTE TO MAGNETIC COPPER-ZINC MOF-74 MATERIALS

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Metal-organic frameworks (MOFs) are porous crystalline materials formed by coordination bonding between organic ligands and metal ions (or metal-oxo clusters). Many of them are being studied for potential application, notably, bimetallic MOFs that generally outperform their corresponding monometallic analogues [1]. Solution synthesis methods lack control over the stoichiometric ratio and the spatial arrangement of the metal centers within the framework. New synthetic strategies, such as mechanochemical synthesis, overcome these issues [2].

Here, three bimetallic MM'-MOF-74 materials, comprised of zinc (II) and copper (II) metal nodes in a 1:1 ratio, were prepared by different mechanochemical approaches and from different polymeric precursors. Synthesized materials are indistinguishable by powder X-ray diffraction (PXRD) while electron paramagnetic resonance spectroscopy (EPR) and magnetic measurements revealed the different distribution of metals in the MOFs. This was furthermore clarified by different mechanisms of framework assembly observed during in situ monitoring of reactions by synchrotron PXRD [3].

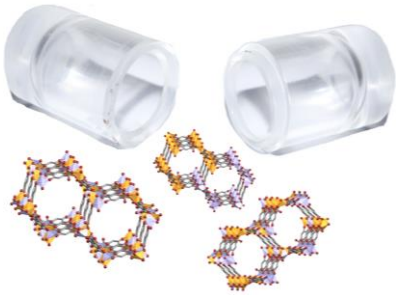

Figure 1. Magnetic Cu-Zn MOF-74 materials synthesized by mechanochemistry.

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CRYSTALS OF COPPER(II) COORDINATION POLYMER WITH MECHANICALLY AND THERMALLY INDUCED MOTIONS

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Stimuli-responsive crystalline materials are of utmost importance at the time as they are prominent candidates for advanced technologies applications, e.g., soft robotics, wearable sensors and flexible electronics, optical waveguides etc., and, up to this time, a number of crystal flexible behaviour due to the various stimuli-type induction has been reported, whereas the most frequent are examinations on crystal responsiveness upon irradiation and heating [1]. Mechanically induced flexibility of crystalline compounds has only recently been observed on organic compounds, and even latterly on crystals of metal-containing solids, that nevertheless quickly imposed as leading choices for flexible crystalline materials due to the presence of metal centre which could account for equipping the crystalline solid with various properties [2,3]. Yet, literature reports on metal-organic compounds exhibiting multi-stimuli responsive crystals are quite scarce [4], despite of their significantly superior potential in high technology applications, as opposed to one-stimuli responsive crystalline compounds, which is only becoming a challenge to be tackled.

For examining external-stimuli responsiveness on crystals of metal-containing compound, a coordination polymer of copper(II) halide equipped with halogen-pyrazine ligand has been synthesized *via* liquid diffusion method. To perform the bending experiments, aciculate crystals have been harvested, isolated, and subjected to the applied mechanical force using modified three-point bending procedure, whereas analogue needle-like crystals were isolated and prepared for experiments of heating. Crystals have been exposed to the stimuli in a controlled manner, and consequent mechanical behaviour was investigated and analysed with respect to a variety of structural features.

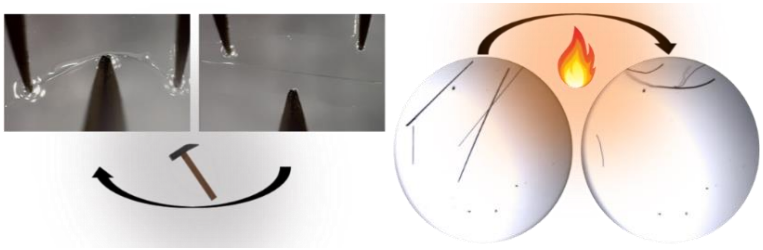

Figure 1. Mechanically and thermally compliant single crystals of copper(II) coordination polymer.

ACKNOWLEDGMENTS

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ARGININE-RICH PEPTIDES VS. LYSINE-RICH PEPTIDES: IMPACT ON DIFFERENTLY CHARGED LIPID BILAYERS

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Peptides that interact with the cell membrane by disrupting it, by passing through it, or by residing at the membrane interface are known as membrane active peptides. Arginine (Arg or R)- and lysine (Lys or K)-rich cationic peptides are known to have antimicrobial activity, since cationic residues attract the peptide to the anionic bacterial membrane [1]. Arg-rich peptides are more prevalent in natural occurring antimicrobial peptides than Lys, implying that guanidinium group in Arg interacts in different way with biological membranes than the amine group in Lys [2, 3]. As antimicrobial peptides (AMP) have potential application as antibiotics, a better understanding of peptide-lipid interaction is essential to decipher their mechanism of action [4]. In order to get more detailed insight into the interaction of cationic peptides RRRRRFF and KKKKKFF, synthesized by solid phase synthesis, and lipid bilayers prepared from anionic 2-dipalmitoyl-*sn*-glycero-3-phosphatidylserine (DPPS) lipid and zwitterionic 1,2-dipalmitoyl-*sn*-glycero-3-phosphocholine (DPPC), we performed a calorimetric and spectroscopic study. For the purpose of determining the impact of peptides on thermotropic properties lipid bilayers, UV-Vis spectroscopy and differential scanning calorimetry (DSC) have been used, and for molecular-level details of their interaction, FTIR spectroscopy has been used.

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THE INFLUENCE OF PRACTICAL WORK AND THE USE OF SCIENTIFIC RESEARCH METHODS ON THE INTEREST IN THE STEM FIELD OF NINE-YEAR-OLD STUDENTS

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The project "Sa STEMom raSTEMo " was developed by the Strategic Plan of the Ministry of Science and Education of the Republic of Croatia for the period 2020-2022[1] Furthermore, it was developed by the "Science, Education, and Technology Strategy" of the Republic of Croatia in the area of lifelong learning [1].

It is necessary to provide children with many opportunities to participate in research activities that correspond to research carried out in science since through the processes of independent experimentation children acquire relevant skills and learns about the processes of science [2]. According to research results, formal knowledge prevails over applied knowledge among children of younger school age [3]. It is necessary to change the existing situation through frequent and continuous cooperation of the subject and class teacher, and by connecting the teaching of the subject nature and society with the teaching subjects of the STEM area.

To improve didactic work in the STEM field in elementary schools, the program "Sa STEMom raSTEMo" was created, which was approved by the Ministry of Science and Education. The one-day version of the program was implemented in 22 schools during the 2021/2022 school year, and 1200 students participated. Assessment of interest in the STEM field will be conducted among students who have participated in the program and their peers in the same schools in the 2022/2023 school year who have not participated in it. These groups will be compared in terms of their interest in the STEM field.

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UNDERSTANDING MECHANICAL REACTIONS USING THE CLASSICAL HAMMETT MODEL

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The ability to predict mechanochemical reaction pathways and kinetics based on the mechanical energy input as well as the characteristics of the targeted chemical reactivity is required for efficient experimental planning. While we have recently established linearity between energy input and reaction progress in a purely mechanochemically activated reaction [1], we have here tested the application of the classical solution-based Hammett correlation in mechanochemical Schiff base formation from *p*-nitrobenzaldehyde and differently substituted anilines [2]. Tracking chemical transformations in real time using in situ Raman spectroscopy enables the examination of the connection between chemical, rheological and kinetic factors. It was shown that the properties of reaction material such as hardness and density affect the elasticity of the collisions in a ball mill and the different course of the reaction. The linear dependence of the reaction probability and the Hammett constants derived from solution indicates that the current models borrowed from physical-organic chemistry can be exploited to further the understanding of milling reactions (Figure 1).

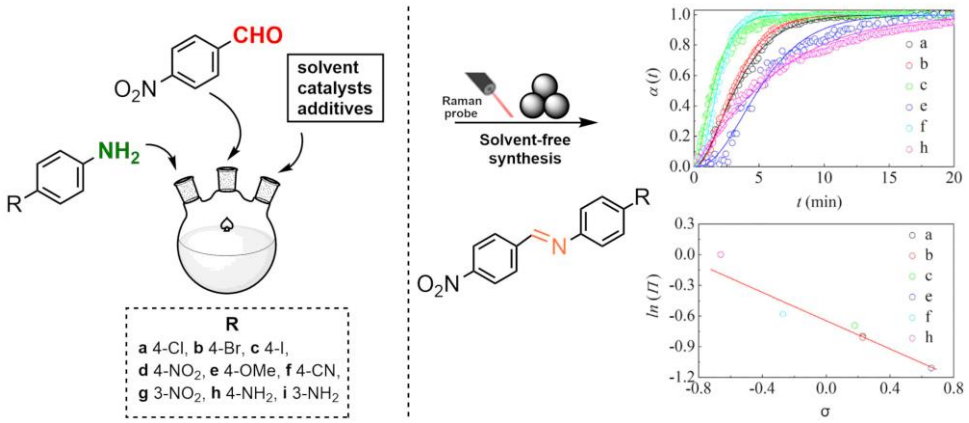

Figure 1. Explanation of molecular structure influence on chemical reactivity in a solid state.

ACKNOWLEDGMENTS

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OBJECT-BASED MAPPING OF RIVER CORRIDOR UNITS USING HIGH-RESOLUTION IMAGERY ON THE ORLJAVA RIVER

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Object-based approach to land cover classification showed to be a powerful tool for automating the analysis of river geomorphology at different spatial scales [1,2]. In this study, we present object-based mapping of the Orljava river corridor based on aerial images of high spatial resolution (0.3 m). The segmentation and supervised classification of aerial images was performed in eCognition software using four spectral bands (Red, Green, Blue and Near-infrared – NIR) and two indices (Normalized Difference Vegetation Index and Normalized Difference Water Index). Classification scheme included five classes: water, fluvial bars and bare ground, sparse vegetation, dense vegetation, and shadows. All five assessed machine learning classification algorithms achieved a satisfactory overall accuracy of approximately 85% with small mutual differences. Supported Vector Machine (SVM) algorithm showed best results for classifying water and shadows. Fluvial bars and bare ground were best classified by K-Nearest Neighbour, sparse vegetation by Bayes, and dense vegetation by Random Forest algorithm. Object-based mapping facilitates the quantification of geomorphological characteristics of rivers such as channel width, sinuosity index, area of bars and islands or length of the riparian corridor. Therefore, the use of remote sensing data and machine learning classification algorithms proved to be sensible for the future assessment of changes in the Orljava river corridor, which are frequent due to flood events and recent engineering works.

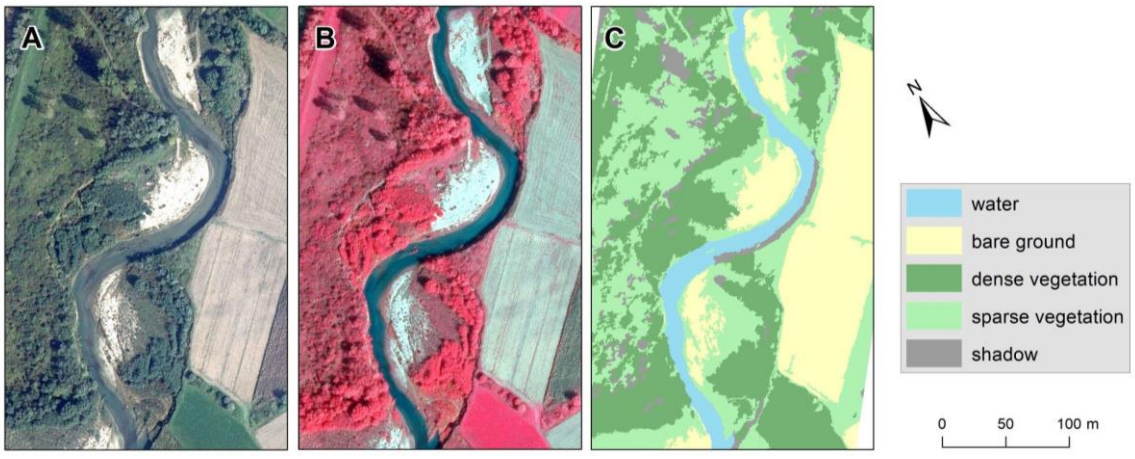

Figure 1. Study area on: A) RGB orthophoto, B) NIR orthophoto, C) classified scene by SVM algorithm

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THE HOLY GRAIL OF MICROPALEONTOLOGY – THE MAGICAL NUMBER 300

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Paleoecology gives us insight into past environments. Following the rule that the present is the key to the past, paleoecology is based on the distribution and abundance of living organisms in interaction with abiogenic and biogenic parameters. Nowadays, statistical analyses became an important tool in paleoecological interpretation, and foraminifera play a key role. Statistical analyses of foraminiferal assemblage can give us information about: the depth of the depositional environment by plankton/benthos ratio; quality of environment (stability, domination of some ecological factor) by dominance indices (Simpson index, Berger-Parker index); biodiversity via Shannon-Wiener and Fisher index; the oxygen concentration via BFOI index [1, 2]; the trophic regime via TROX model [3]; the ecological quality condition via AMBI-Foram or EcoQs indices.

So, this is how we come to the magical number 300. Foraminiferal assemblage must be prepared properly to obtain valid data from ecological indices. After the standard wet-sieving method each dried residue has to be split into aliquots by a microsplitter. Even using a microsplitter causes some kind of selection among foraminiferal tests. The practical use of this method has shown that 300 specimens are optimal for getting correct and adequate results for paleoecological interpretation.

One question remains: To what extent are these randomly picked 300 specimens biased by gravity? To test this hypothesis small research on the Miocene samples was performed [4]. From the taken aliquot (0,25 g), all specimens were hand-picked, a total of 393 benthic specimens and 657 planktonic specimens. The number of picked specimens was too high for using the PAST program because it works with the magical number 300, so the rarefication technique had to be applied. Calculating the same indices on foraminiferal assemblage with more than 1000 specimens and foraminiferal assemblage with 300 specimens proved that gravitation is of negligible effect.

No matter if, specimens in your foraminiferal assemblage are different in size or shape if they are picked from one tray or several ones if you have counted 300 specimens from your picking tray be sure that they will tell you quite an interesting story of their environment.

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WILDFIRES RESEARCH IN CROATIA: IMPORTANCE OF IRON OXIDES AND HYDROXIDES

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With the recent occurrence of increased wildfire events, the scientific community became more aware of strong wildfire impacts on different ecosystems. In the course of climate change, wildfires have lately also affected atypical areas such as the boreal forests [1]. Research of wildfires is a complex activity due to existence of short- and long-term effects caused by fire. Wildfires change physical, chemical, and biological properties of soil. Some of them are soil structure and pH, nutrient content and availability, soil biomass content, cation exchange capacity, soil mineralogical composition and others. Since the minerals are the most abundant soil constituent, their thermal changes could be used for characterization of wildfire duration and intensity. Also, those thermal changes could affect ecosystems in a way of redistribution and speciation of potentially toxic elements [2]. Iron oxides and hydroxides can be found in various soil types and are strongly sensitive to temperature change what makes them a promising tool for the study of wildfires. Due to the increased temperatures caused by the wildfire, thermal transformations of weakly magnetic Fe oxides and hydroxides (ferrihydrite, lepidocrocite, goethite and hematite) into stronger magnetic phases such as maghemite or magnetite occur [3]. Magnetic susceptibility (MS) is essentially a measure of how "magnetizable" a mineral is and incorporated with some other analytical methods can be used for tracking the thermal changes of Fe oxides and hydroxides [4]. The preliminary MS measurements were performed on soil and ash samples from three wildfires occurred in Croatia in 2021. and 2022. Analysis of measured MS values, show significant difference between unburned and burned soil in a way that burned soil tend to have much higher MS values than unburned. Also, there is a correlation between MS values and a burning intensity, where the higher MS values are proportional to stronger burning intensity as a result of more complete transformations of Fe oxides. Further research is focused on determination of more detailed magnetic properties of burned soil and ash by using sophisticated magnetic analytical instruments. This examination should show magnetic carriers in burned soils and finally the temperature to which the soil was exposed during wildfires.

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BIOMETRIC CHANGES IN PLANKTONIC FORAMINIFERA *Pseudohastigerina micra A* FROM THE UPPER EOCENE SEDIMENTS OF THE ISLAND OF HVAR

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Nine samples were collected from a 50 m thick sediment succession at Zaraće cove, island of Hvar. Planktonic foraminifera tests were extracted from the samples and in six samples foraminifera were abundant to allow further paleoecologic studies. The samples fall within the E15, *Globigerinatheka index*, planktonic biozone of [1], which corresponds to upper Eocene (Priabonian) age. During this age average sea temperature was on a steady decline. The hypothesis of this study was to track changes in foraminiferal tests sizes to detect changes in temperature, knowing that tests are getting smaller and smaller as temperature decreases [2]. For this *Pseudohastigerina micra* (Cole 1927) was selected for the study. The species was abundant throughout most of the Zaraće section and, up to date, the only biometric study was done solely for phylogenetic purposes [3]. Around 50 specimens (tests) of *P. micra* were randomly picked from the 63-250 µm size fraction of each of the five samples (those samples that contained sufficient number of individuals). Each test was observed under a stereoscopic microscope and photographed in side and aperture views. Using ImagePro 4 software following test parameters were measured: maximum diameter of the test, height of the final chamber, width of the final chamber and aperture shape. In the older part of Zaraće section, *P. micra* shows a steady decrease in maximum test diameter, width and height of the final chamber, with lowest values measured in the sample taken just below the 22nd meter of the section. This coincides with a decrease in planktonic foraminifera diversity and may point towards increasing environmental stress. Towards the younger part of the section (above the 22nd meter), and up until foraminifera become rare or absent, *P. micra* tests have features similar to those found in the oldest part of the section.

ACKNOWLEDGMENTS

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HOW NATURE RESTORES ITSELF: THE STORY OF SOIL FORMATION ON TWO COAL COMBUSTION RESIDUES DISPOSAL SITES IN CROATIA

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Coal has been one of the dominant energy sources in the last two centuries [1]. Despite the possible decline in coal consumption, the legacy of coal will remain in the environment in the form of disposed coal combustion residues (CCR) [2]. The total number of coal ash disposal sites and their status (lined, open) in the world is unknown, which is concerning because the evidence of pollution caused by their disposal is undeniable [3]. Here we present a study of indicators of early pedogenesis on two ~40-year-old CCR landfills. We observed changes in pH, mineral assemblage, organic matter, texture of the material, and nutrient content. All of these mentioned indicators help us understand the evolution of CCR landfills, which will later help us understand how leaching of pollutants is affected by the natural succession of these landfills.

ACKNOWLEDGMENTS

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SPONGES FROM THE MIDDLE MIOCENE DEPOSITS OF THE NORTH CROATIAN BASIN

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During the middle Miocene, the area of today's northwestern Croatia (North Croatian Basin) was flooded by the Paratethys sea, which spread over the greater area of Europe and Asia. Diverse organisms lived in the warm Miocene sea, whose fossil remains are preserved in sedimentary rocks, and among them are fossil sponges. Sponges (Porifera) are multicellular animals with a very simple structure and do not have real tissue or organs, but their cells possess a considerable grade of independence. They inhabit all aquatic environments, and the oldest sponge fossils are known from the Praecambrian. Sponges that have a mineralized skeletons (separate or fused spicules) made of calcium carbonate or silica in an opaline form have a good chance of being preserved as fossils [1]. Completely (whole-bodied) preserved sponge fossils are rare, while fossil spicules, which are scattered in the sediment, are much more common. By studying fossil spicules, it is possible to reconstruct former sponge communities, and obtain information about the environment in which they once lived (water depth, Ph, temperature, oxygen content...). Samples of clayey-marly sedimentary rocks were collected on the northwestern slopes of Medvednica Mt. (localities Gornje Vrapče and Podsusedsko dolje) and on the northern slopes of Krndija Mt. (locality Bukova Glava). The wet sieving method was applied, so that 200 g of sediment is first crushed into smaller pieces and the sediment is soaked in a solution of water and hydrogen peroxide for 48 hours, in order to separate the organic from the inorganic part. Then the sediment is washed through a system of sieves with a mesh diameter of 500, 200, 125 and 63 µm. After drying, the sample is ready for microscopic analysis. In addition to spicules of sponges, benthic and planktonic foraminifera, ostracods, bryozoans, urchin spines and snails were found in the analyzed samples. The spicules are well preserved, and are most numerous in the 125 µm and 63 µm fractions (megascleres). During the Miocene, sheltered habitats of inner/middle shelf environments of the North Croatian Basin were inhabited with extremely abundant and diverse siliceous sponge assemblages. Most of the collected spicules are monaxone, or simple trienes, probably belonging to demosponges, but it is very hard to determine them in detail [2]. Some of the collected amphitrianes spicules, short-shafted dichotriaenes can be well compared with spicules from other localities of the central Paratethys sea.

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TEPHRA DISPERSAL AND DEPOSITION ACROSS THE PANNONIAN BASIN AND THE DINARIDES FROM A ~15.3 MA (MIDDLE MIOCENE) EXPLOSIVE ERUPTION

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Volcanic events were frequent during formation of the Pannonian Basin. Repeated explosive eruptions of silicic magmas produced volcaniclastic deposits that covered a large area, although presently most of them are overlain by younger deposits. Mountains surrounding Pannonian Basin host well exposed outcrops of the Early and Middle Miocene deposits with volcaniclastic horizons, which provide detailed evidence of volcanic events. At Mt. Požeška gora, the thickest primary volcaniclastic layer was analyzed using a ”multi-proxy“ approach (sedimentology, high-precision zircon geochronology, $^{40}Ar/^{39}Ar$ radiometric dating, volcanic glass geochemistry) and dated to ~15.3 Ma [1]. Volcaniclastic layers potentially contemporaneous with Požeška gora ~15.3 Ma horizon were recorded regionally, from the Vienna Basin [2] to the North Alpine Foreland Basin [3] as well as Dinaride Lake System [4]. In this research, we analyzed three volcaniclastic layers variously distanced from the Požeška gora site to determine the wide spread ~15.3 Ma volcanic event.

Our study shows that using data from a single glass shard geochemistry and zircon geochronology enables correlation of Požeška gora volcaniclastic horizon with Kuchyňa (Vienna Basin), Lučani (Sinj Basin) and Čučerje sites (Mt. Medvednica). These sites are 100–300 km away from Mt. Požeška gora locality. This volcanic event can be used as a marker horizon for the Neogene stratigraphy in the wider area of the Pannonian Basin.

ACKNOWLEDGMENTS

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QUINE'S SET THEORY WITH ATOMS

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Quine introduced New Foundations (NF) in 1937 [3] with the intention of preserving as much of Whitehead--Russel's type theory as possible, also using some of Zermelo's ideas. The theory was very much alive until 1953 when Specker proved that the axiom of choice does not hold in NF. New interest for the theory reappeared when Jensen proved [1] that NF with atoms (NFU) is consistent. Theory NFU, supplemented with the axiom of infinity (Inf) and the axiom of choice (AC), is a strong enough theory that all mathematics can be developed in it. Therefore, we will argue that NFU+Inf+AC is a theory that can be used as a foundation for mathematics.

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CLT FOR THE PERIMETER OF CONVEX HULLS SPANNED BY TWO INDEPENDENT RANDOM WALKS

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In this research, we limit ourselves to R^2 and consider two independent random walks with linearly independent drift vectors. If we denote the perimeter of the obtained convex hull up to time n with L_n, we show that $1/\sqrt{n}(L_n - E(L_n))$ converges in distribution to $N(0, \sigma^2)$, where the constant $\sigma^2 > 0$ can be explicitly expressed. Ultimately, the idea is to expand this idea to more walks in multiple dimensions and for other intrinsic volumes.

This research expands the idea made in the papers [1], [2], and [3].

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CLASSICAL FRIEDRICHS OPERATORS

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The theory of abstract Friedrichs operators, introduced by Ern, Guermond and Caplain (2007), proved to be a successful setting for studying positive symmetric systems of first order partial differential equations (Friedrichs, 1958), nowadays better known as Friedrichs systems. Recently, Antonić, Michelangeli and Erceg (2017) presented a purely operator-theoretic description of abstract Friedrichs operators, allowing for the application of the universal operator extension theory (Grubb, 1968).

In this presentation, we shall see some applications of Friedrichs operators and recent advancements in the theory.

ACKNOWLEDGMENTS

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TRACE MAXIMIZATION ALGORITHM FOR THE APPROXIMATE TENSOR DIAGONALIZATION

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In recent decades, tensors, or multidimensional arrays, have found a wide spectrum of applications. Tensor decompositions are used in independent component analysis and signal processing problems like blind source separation, with applications in chemometrics, biomedical data analysis, digital communications, seismic monitoring and more.

Generally, unlike the matrices, higher order tensors can not be diagonalized, meaning transformed so that all its values but the diagonal ones are zero. We develop a Jacobi-type algorithm for the approximate diagonalization of tensors of order d≥3 via tensor trace maximization. This is an alternating least squares algorithm and the rotation matrices are chosen in each dimension one-by-one to maximize the tensor trace. We show that the algorithm converges to the stationary point of the objective function and present several numerical examples. This talk is based on the work done in [1].

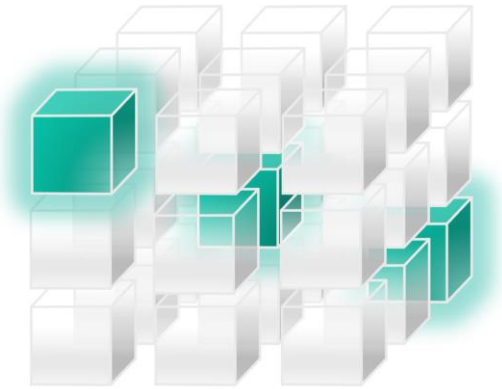

Figure 1. Third order tensor.

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AN APPROXIMATE MAXIMUM LIKELIHOOD ESTIMATOR OF DRIFT PARAMETERS IN AN ELLIPTIC DIFFUSION

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In many areas of science, there are phenomena that can be modelled using a system of differential equations. Such a model is deterministic, but often it is naturally to assume that there is some kind of noisy behaviour. The mathematical model used to describe such a system is called the diffusion process and is represented by a multidimensional stochastic differential equation. The diffusion model can be understood as a two-part model consisting of a drift part and a diffusion part. The drift part is a deterministic part that describes the average behaviour of a system, while the diffusion part includes randomness due to Brownian motion. Of great interest are diffusions with a random component in each dimension of a system, which is formally achieved by assuming a uniform ellipticity condition for the diffusion part. Moreover, this condition ensures the long-term stochastic stability of a system. For this reason, the so-called elliptic diffusion is one of the most important stochastic modelling tool in finance, biology and medicine. In our work, we are concerned with the estimation of drift parameters in such models. The maximum likelihood method is widely used, but the resulting estimators are often incomputable in practise, so we use its discretized version, called the approximate maximum likelihood method. Our main theorems describe the relationship between the estimators resulting from these two methods and provide certain generalization of the results from [1].

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SIMULATING IMPACTS OF RISING SEA LEVEL AND STORMS ON GRAVEL BEACH PLOČE

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Croatia has mostly small gravel beaches that are increasingly vulnerable to the pressures of tourism and climate change. In the absence of a national coastal management strategy [1,2] local municipalities are left tending to beach erosion with nourishment in order to meet the expectations of visitors. Future sea level rise [3] will worsen beach and shoreline retreat across the Mediterranean [4,5], accelerating erosion processes in Croatia as well. XBeach-Gravel is a numerical, non-hydrostatic, model aimed to simulate the impact of storm events on gravel beaches [6], including erosion. Using XBeach-Gravel, the impact of storm events on a small gravel beach Ploče, located near Rijeka, are investigated along with the potential effects of different future sea levels.

ACKNOWLEDGMENTS

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INTERACTION OF COPPER WITH HUMIC ACID IN AQUEOUS SOLUTION

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Copper (Cu) is an essential trace element in biochemistry and physiology of all organisms [1]. Due to its ability to undergo redox changes between Cu (I) and Cu (II) oxidation states, Cu is an important catalytic cofactor in redox reactions involved in electron transfer [2,3]. Nevertheless, high concentrations of free Cu ions are toxic to the most of living organisms, including marine phytoplankton [4,5,6]. In seawater, more than 99% of dissolved Cu is complexed with organic ligands, which results in femtomolar levels of free, toxic Cu ion [7]. Although the exact chemical composition of Cu- complexing ligands is not known, ligands are divided in two ligand classes: L_1 and L_2. The stronger Cu binding ligand class, L_1, was reported to contain thiol and humic substances [8,9]. Furthermore, a portion of weaker class ligands, L_2, that had molecular weight distribution that were consistent with humic substances, was reported [10].

In this work we present our research on Cu interactions with humic acid (HA) in aqueous solution, with emphasize on Cu (II) reduction and its efficiency, as well as stability of Cu(I) complexes with HA. The effects of reaction conditions, such as pH, Cu to HA ratio and presence of chloride ions, are also evaluated. Multimethod approach, including spectrophotometric and electrochemical methods, is used for determination of Cu(I) and Cu(II) in model solutions containing HA.

ACKNOWLEDGMENTS

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WHAT CAN WE LEARN FROM THE GEOMETRY OF KVARNER AREA TIDAL NOTCHES?

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Tidal notches are characteristic erosional forms that develop on relatively sheltered carbonate rocky coasts with small tidal range [1,2]. The bioerosion rate is generally highest near Mean Sea Level (MSL) and gradually decreases towards the upper and lower limits of the intertidal range. As a result, erosional, groove-like, feature develop with typical U or V shaped form [3]. If found above or below present sea level they are considered to be one of the best geomorphological indicators of local sea-level change, with up to decimeter confidence. Inward depth of a tidal notch profile provides information on the duration of relative sea level stability. In addition, its profile provides information on the speed (slow or rapid) of its emergence or submergence [3]. The Kvarner area is a semi-enclosed channel part of the Adriatic Sea, located between the Istrian peninsula and the Vinodol-Velebit coast. It consists of tectonically deformed and karstified Mesozoic to Cenozoic predominantly carbonate rocks [4,5]. As the rest of the Eastern Adriatic coast, it shows typical morphologic features associated with the chemical dissolution of carbonates, inherited from the karstification processes [6]. Late Pleistocene-Holocene relative sea level changes along the eastern Adriatic coast are still not completely resolved, mostly due to the intensive and complicated regional and local neotectonics [7]. In the Kvarner area, tidal notches are located deeper than 0.5 m below present MSL [8,9]. Therefore, their detection and measuring are challenging. The different depth of tidal notch is a consequence of recent tectonic movements in the seismotectonically very active Kvarner area. Currently, a comprehensive survey of the coasts of Krk, Prvić, Plavnik, and Cres islands is being conducted as part of ongoing research. The study focuses on analyzing the geometry of tidal notches using the methodology of Pirazolli (1986) and Benac et al. (2004). To ensure accuracy, the biological mean sea level is used as a reference level for measurement, based on the biological zonation in the intertidal zone. The resulting data on the submerged tidal notches will be processed to gain a better understanding of the relative sea level changes and regional tectonic processes.

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INTEGRATION OF CONDITION INDEX INTO FISHERIES MANAGEMENT DECISION-MAKING

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Condition index, a simple metric calculated from commonly available biometric data, is an indicator of individual fish status [1]. Since individual performance defines population dynamics, use of condition index has also been suggested (but not included) in fisheries management [2]. Inclusion is lagging because correlation between individual-level processes and population-level responses is poorly understood, leaving interdependencies between the condition index and population status overlooked and/or misinterpreted by the managers. Moreover, practical means of including condition index into management decision-making are scarce, hindering its implementation.

We adopt a composite modelling approach to investigate the link between individual condition and population status, and use the insights to promote a practical way to operationally incorporate the condition index into fisheries management. We suggest a careful integration of condition index as a supplementary validation tool against standard stock assessment, where agreement between the two independent assessments leads to decision-making, while discrepancy suggests additional research would be beneficial (Figure 1).

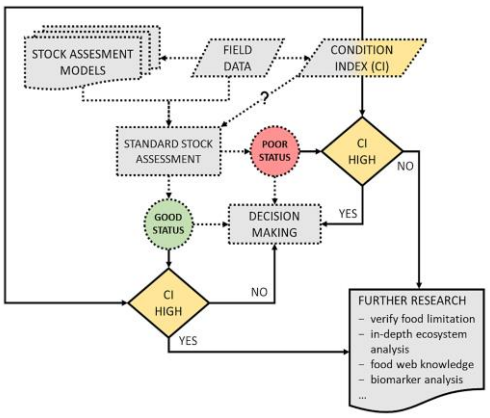

Figure 1. Suggested integration of condition index into fisheries management decision-making [3].

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DYNAMICS AND DIVERSITY OF VIBRIO SPECIES IN EASTERN ADRIATIC BIVALVE AQUACULTURE

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In Croatia, traditional bivalve aquaculture means that whole bivalve life cycle is completed in natural environment. Hence, these organisms are highly influenced by environmental changes. Moreover, during their feeding process, they accumulate large number of microorganisms. Among them, bacteria of the genus *Vibrio* are of particular concern, owing to their association to diseases of marine organisms and humans [1]. Results of previous research show that with seawater temperature increase, *Vibrio* bacteria become more abundant [2]. Therefore, aim of this study was to analyze how environmental parameters affect abundance and diversity of *Vibrio* sp. species.

Study was conducted on two locations known for traditional bivalve aquaculture - Lim Bay and Mali Ston Bay. We sampled seawater, sediment and tissue (hepatopancreas and gills) of two most important aquaculture bivalves in Croatia - European flat oyster, *Ostrea edulis* Linneaus, 1758 and Mediterranean mussel, *Mytilus galloprovincialis* Lamarck, 1819. We determined physico-chemical parameters of seawater. Additionally, culturable heterotrophic and total *Vibrio* bacteria in seawater, sediment and shellfish tissues were isolated on Marine agar and *Vibrio* selective TCBS medium on 22°C and 35°C. Furthermore, we identified *Vibrio* clades with MALDI-TOF MS.

Results show that both culturable heterotrophic and total *Vibrio* bacteria in seawater, sediment and bivalve tissues were higher in Lim Bay. Temperature was the most dominant environmental parameter that influenced the both abundance and diversity of *Vibrio* species. Temperature related fluctuations showed that *Vibrio* species are more abundant on higher temperature and this trend is most visible in tissue samples. Our results raise questions on how further perturbation of environmental conditions related to global warming, may affect the susceptibility of farmed bivalves to colonization by *Vibrio* pathogens.

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VIBRIO SPP. ABUNDANCE AS AN ADDITIONAL INDICATOR OF WATER QUALITY: LESSONS FROM MALI STON BAY

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Coastal areas support more than 40% of human population and 60% of national economies, however, the related anthropogenic pressures endanger ecosystem services [1]. Science-based coastal management practices aim to ensure the preservation of marine ecosystems and related services, but the quality of management highly depends on environmental indicators used for decision-making [2]. We used a three-year dataset from Mali Ston Bay to examine seasonal variability of environmental and bacterial indicators and to assess whether *Vibrio* spp. abundance contributes to water quality assessment. We compared bacterial indicators (heterotrophic bacteria, total coliforms, *E. coli*, enterococci, and *Vibrio* spp. abundance) to estimate: (i) reach of emissions from the fish farm, (ii) suitability of *Vibrio* spp. as a measure of pollution, and (iii) variability of *Vibrio* spp. abundance with respect to other potential pathogens (*E. coli* and enterococci), and heterotrophic bacteria in general. We found no differences between fish farm and control site in environmental conditions, organic matter, and bacterial abundances. Expectedly, *E. coli* and total coliforms thrived during the warm season, while, surprisingly, heterotrophic bacteria, enterococci, and *Vibrio* spp. were more prevalent in the cold season. *Vibrio* spp. abundance across seasons and depths showed that these genera is a strong candidate for inclusion in monitoring strategies as it provides additional water quality information critical for adapting coastal management strategies.

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WHY USING HIGH RESOLUTION CLIMATE MODELS IN THE ADRIATIC SEA MATTERS

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The Adriatic climate is strongly affected by complex orography and ocean geomorphology, land-sea contrasts, intense air-sea interactions, etc. and is thereby extremely challenging for adequate simulation in climate models. Global and regional climate models at a relatively coarse spatial resolution (from 100 to 10 kilometers) are generally not suitable to reproduce atmospheric processes in the Adriatic, while coupling with the ocean represent another challenge in terms of numerical cost. However, coupled atmosphere-ocean models at the kilometer-scale have the advantage of better capturing critical processes such as orographically-driven variations in precipitation, winds, surface energy balance, etc., particularly during extreme events. The Adriatic Sea and Coast (AdriSC) kilometer-scale modelling suite has thus been recently developed [1] to accurately reproduce the atmospheric and oceanic processes at different temporal and spatial scales over the Adriatic and northern Ionian Sea, ranging from the impact of climate change on extreme events to the operational forecast of extreme sea-levels along the Croatian coasts.

Within the AdriSC modelling suite, the climate component is dedicated to the study of long-term kilometer-scale atmospheric and oceanic processes occurring in the Adriatic region. Two approaches have been applied. First, long-term AdriSC climate simulations have been set-up to cover the present climate for the 1987-2017 period (evaluation run) and a far-future high-emission climate under the Representative Concentration Pathway (RCP) 8.5 scenario for the 2070-2100 period. Second, short-term simulations over a significant number of extreme events under present (1977-2017 period, evaluation runs) and projected future climates (RCP4.5, RCP8.5, 2060-2100 period) have been used to prove the added value of the AdriSC model. All simulations for the far-future simulations were derived using the pseudo-global warming (PGW)method, which has recently extended to coupled atmosphere–ocean models. Itimposes an additional climatological change (e.g., a temperature change representative of the increase in temperature between past and future climate) to the forcing used to produce the evaluation runs.

In this presentation I will provide an overview of the AdriSC modelling system's set up, and of its applications on studying Adriatic climate under current and future conditions. In addition, I will also demonstrate that the AdriSC kilometer-scale model can be used to study a wide range of atmospheric and oceanic processes in past and future climate in the Adriatic region as its resolution captures enough details to accurately reproduce even the most extreme events.

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FRUSTRATING QUANTUM BATTERIES

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We are at the verge of the Quantum Technology Revolution: quantum mechanics allows for phenomena that have no classical counterparts and which can be harvested for new technologies. An example of the emerging quantum technologies are quantum batteries, i.e. quantum mechanical systems that can store and transfer energy in a coherent way. While the practical implementation of such devices is still far from becoming reality, a serious effort is being devoted in understanding their advantages and limitations, using different platforms and protocols. As it has been recently demonstrated [1, 2] that the introduction of topological frustration in one-dimensional spin-1/2 chains can strongly modify the low energy properties of these systems, we investigate the performance of a quantum battery realized through such frustrated chains and introduce a novel, natural, dephasing mechanism [3] that show their superiority compared to their unfrustrated counterpart. We quantify this superiority in different ways (charging and discharging times, energy output, efficiency, stability...) using the notion of ergotropy [4], that is, an amount of energy available to extract work.

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CHARGE DENSITY WAVE GROUND STATE IN THE INTERCALATED GRAPHITE CaC_6

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We present an analytical model of the charge density wave instability in the graphene sheets within the intercalated graphite CaC_6 compound. The instability yields the experimentally observed [1] uniaxial charge stripes of periodically modulated electron density, coupled to the softest phonon mode of the superlattice consisting of the Ca atoms intercalated between graphene planes. The Fermi surface of the chemically doped graphene undergoes the novel type of instability driven by the mechanism that gains the condensation energy of the stripe state by the topological reconstruction of the Fermi surface. This mechanism appears to be entirely different from the one based on the Fermi surface nesting [2], which has been considered a paradigm in the present literature concerning the onset of charge density waves.

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OPTICAL PROPERTIES OF ALUMINIUM ISLAND FILMS

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Metals islands films (MIFs) display a highly tunable optical behaviour which results in a wide variety of photonic applications, including colour coatings [1] and selective absorbers [2]. In order to incorporate MIFs as building blocks in the design of optical coatings, a precise knowledge of their optical properties is needed. Various approaches of modelling are used to describe the optical responses of these IFs. Classical effective medium theory approach , multiple-oscillator approach or non-parametric models are some of the models that have been successfully used. In the present work, aluminium IFs which show strong potential for the practical implementation of plasmonic-based structural colours [3] are chosen. We investigate the above mentioned approaches for the optical characterization of Aluminium IFs via a round robin test using spectroscopic photometric and ellipsometric data. In addition, the presence of interband transitions in the near-infrared range which overlaps with the free electron response makes the characterization of Al MIFs particularly challenging. This overlapping gives rise to a doubled peak resonance which makes the tunability of plasmons in Aluminium more interesting [4].

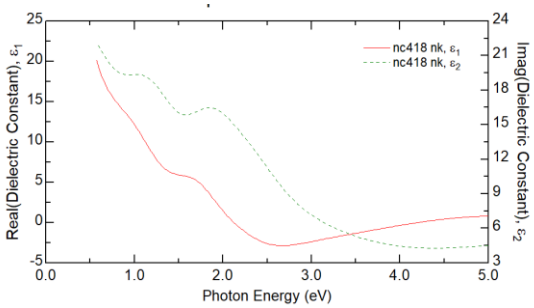

Figure 1. Double peak response of dielectric function.

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COMPLEXITY AND NEURAL NETWORKS

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One of the significant hurdles in investigating large quantum many-body systems is the fact that the complexity of the state describing the system exhibits an exponential growth, therefore the analysis quickly becomes infeasible on classical computers. Recently, artificial neural networks have been successfully utilized to extract useful features which could provide an efficient way to describe many-body quantum systems [1][2]. In our work we decided to test their accuracy by investigating integrable physical systems of different complexity [3], namely quantum Ising model, which, being analytically solvable in both the presence or the absence of frustration [4][5], provides a convenient control benchmark for the obtained numerical results. We show that the increase in the amount of complexity in the ground state of the spin chain has a measurable influence on the results obtained from the neural network thus providing us with new knowledge in understanding the inner workings of neural networks.

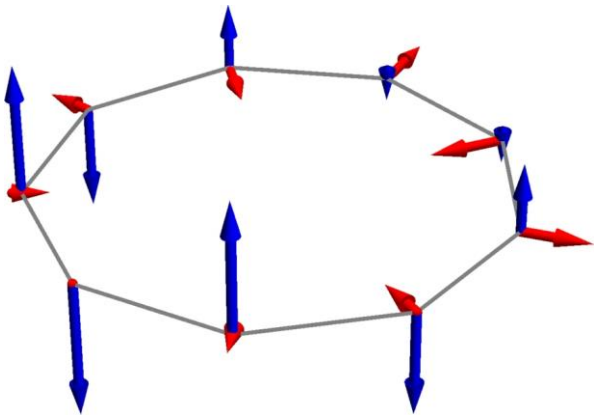

Figure 1. Quantum Spin Chain models offer rich phenomena while still maintaining analytical tractability making them suitable for interpretable machine learning analysis [4].

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OPTIMISATION OF THE SEARCH FOR NEW HIGH MASS HIGGS BOSONS IN THE FOUR-LEPTON CHANNEL WITH THE CMS EXPERIMENT

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Possibly the most well-known achievement made in CERN was the recent (2012) discovery of the Higgs boson particle. It was a great success as it represents the confirmation of the theoretical mechanism that explains how all particles gain mass - through an interaction with the Higgs field. The mass of the Higgs boson itself has been determined and measured with rising accuracy; in 2019 the CMS collaboration has announced the most precise measurement of this property so far: 125,35 GeV with a precision of 0.15 GeV, or 0.12% [1]. The particle that was found and studied extensively is compatible in its properties to the one predicted by the Standard Model (SM). However, the Standard Model is known to have problems in explaining some phenomena such as gravity, dark matter, neutrino mass, which are explained by other theories, or not yet explained at all. So, beyond-the-SM (BSM) physics research and theories are brewing, looking for answers in other ways, using different strategies. One of such being the search for additional heavy scalars, that would prove the presence of a non-minimal Higgs sector. The existence of such a sibling Higgs boson is motivated in many BSM scenarios, so the search for additional scalar resonances in the full mass range accessible at the LHC remains one of the main objectives of the experimental community [2]. Research of some possible optimisations of the high-mass Higgs boson decaying to 4 leptons analysis is presented. The full Run 2 data (2015-2018) collected by the CMS experiment in the Large Hadron Collider is used. The study is carried out as part of the effort to make the search for new scalars (heavy Higgs bosons) more efficient. There are three parts of the analysis conducted. The first is comparing two data samples, before and after an updated calibration of the detector. Next, a study is performed to try to determine whether it is possible to loosen some restrictions in the analysis with a goal of improving the results, while also controlling the "explosion" of noise events. Finally, categorisation of the production mode of the events (how the Higgs boson is created) is explored, taking into consideration the values of the discriminating variables. For each topic, the methods of work are explained and results shown.

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EXPERIMENTAL HEAVY ION INDUCED X-RAY PRODUCTION CROSS SECTIONS FOR TOTAL ION BEAM ANALYSIS

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Particle Induced X-ray Emission (PIXE) spectroscopy remains one of the most widely used Ion Beam Analysis (IBA) techniques for accurate quantitative analyses of elemental concentrations in materials. Synergies of this technique with other IBA methods that provide structural information such as depth profiles (e.g. Rutherford Backscattering Spectroscopy (RBS)), have proven to be powerful non-marking analytical tools applicable to a vast number of scientific disciplines. While the use of protons for such a synergistic approach is well practiced, the implementation of PIXE concurrently with other IBA techniques using heavier projectile ion beams is yet to be realised [1]. This limits the adoption of a heavy ion Total Ion Beam Analysis (TIBA) approach inclusive of PIXE, such as to detect both particle scattering and photon emission processes to consolidate the description of a material (i.e. extract Hydrogen – Uranium elemental concentrations) under analysis [2]. Although Heavy Ion PIXE ought to show higher sensitivity due to relatively higher interaction cross sections compared to those induced by protons at the same ion velocity, widespread implementation of HI—PIXE remains constrained by the lack of reliable ionization cross section data [3]. This is fundamental for accurate quantification of experimental PIXE spectra. The sparse population of the current cross section database thus requires both experimental cross section measurements for the validation of theoretical models of predictions [4]. This presentation therefore describes measured experimental cross sections at the Laboratory for Ion Beam Interactions (LIBI) at the Ruđer Bošković Institute, and at the iThemba Laboratory for Accelerator Based Sciences (LABS) in South Africa. The description also includes the development of a semi-empirical approach for the approximation of heavy ion induced X-ray production cross sections. Experimental and semi-empirical datasets are then compared to theoretical predictions and described in terms of the dominant projectile – atom ionisation mechanisms.

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SYNTHESIS AND CHARACTERIZATION OF Fe_2P AND Mn_2P

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Binary transition metal phosphides (M_2P, where M is a transition metal) are extensively studied due to their rich magnetic properties and potential application like permanent magnets [1]. Among them, ferromagnetic Fe_2P (T_C~214 K) exhibits the largest magnetocrystalline anisotropy [2]. Particular advantage lies in its easily controllable magnetic properties by pressure, temperature, magnetic field, and chemical substitution [1]. In this work, we report on the optimization of the growth conditions for Fe_2P and Mn_2P single crystals by Sn flux and chemical vapor transport methods. Both Fe_2P and Mn_2P crystalize in hexagonal structure (space group: $P\underline{6}2m$). The grown crystals have been characterized by powder and single crystal x-ray diffraction as well as electrical transport measurements. Mn_2P exhibits antiferromagnetic transition around 108 K, as reported in an earlier study [3]. Despite numerous studies on Mn_2P and Fe_2P, their pressure-temperature phase diagrams have not yet been fully investigated. Future research plans will be discussed.

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INFLUENCE OF THE PHITS MONTE CARLO CODE STEP SIZE LIMIT AND THE CALCULATION METHOD ON THE VALUE OF THE LINEAR ENERGY TRANSFER FROM PRIMARY PROTONS IN RADIOTHERAPY

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Unique to the energy loss of protons and heavier charged particles penetrating through a material (the Bragg curve) is the deposition of a large part of the energy in a short distance at the end of their path (the Bragg peak). Linear energy transfer (LET) is related to the radiobiological effect of radiation in matter and is therefore important for radiotherapy planning.

To obtain reliable LET values, usually Monte Carlo (MC) codes, which use interaction cross sections and random number generators to simulate the particle transport, are used. In this work, PHITS (Particle and Heavy Ion Transport Code System) version 3.29 [1], a MC simulation toolkit, was used to calculate the LET of primary protons in a radiotherapeutic beam along the Bragg curve in a water phantom. The first objective was to use PHITS to investigate how the calculated LET values depend on the calculation method. The five methods were: using the most likely LET spectrum value; using the most likely energy spectrum value and converting to LET using PSTAR [2]; calculating the track- or dose-averaged LET; dividing the total deposited energy by the total track length of the primary protons. The second objective was to investigate how changing the maximum allowed tracking step length (step size limit) across the range of 1 to 500 µm obtained with PHITS compares to the results obtained with the same method, but with another MC code: Geant4 version 10.0 [3].

For a 79.7 MeV proton beam, the relative differences between the LET values obtained by different calculation methods were less than 5% before the Bragg peak and increased sharply to the maximum of 70% at the Bragg peak region, where the maximum LET value was close to 20 keV/µm. Preliminary results for the track-averaged LET show that the relative difference due to the step size limitation obtained by PHITS was less than 1% before the Bragg peak, with a maximum of about 10% at the peak, which was less than the 34% difference found with Geant4.

The different LET calculation methods give LET values that differ by a factor of up to 1.7. Compared to Geant4, the track-averaged LET obtained with PHITS is less dependent on the step size limit.

ACKNOWLEDGMENTS

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Er^{3+} DOPED TELLURITE GLASS FOR WHISPERING GALLERY MODE MICROSPHERE LASER PRODUCTION

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Whispering gallery mode microspheres have garnered considerable attention due to their application in signal processing and telecommunications. Unique properties such as high-quality factor and small mode volume of whispering-gallery mode microspheres make them suitable for laser applications with a low pumping power requirement and narrow emission linewidth [1]. Tellurite glass is a promising material for making microlasers because of its high transparency range, high refractive index, and it has been proven as a good host for rare earth ions leading to powerful and broad stimulated emission cross section [2]. We reported lasing in Er^{3+} doped tellurite glass microspheres fabricated using the plasma torch method. $15Na_2O_25WO_360TeO_2$ doped with 0.5 mol% Er^{3+} sample is used for the fabrication of microspheres. When glass grains are passing through an electric arc from the plasma torch they will acquire a spherical shape due to surface tension. Fabricated microsphere is glued to a tapered fiber. Laser light from the pump is coupled to the microsphere through a half-tapered fiber. An optical spectrum analyzer receives the counter propagating light from the microsphere. A pump laser of 980 nm is used to achieve the laser emission at 1570 nm.

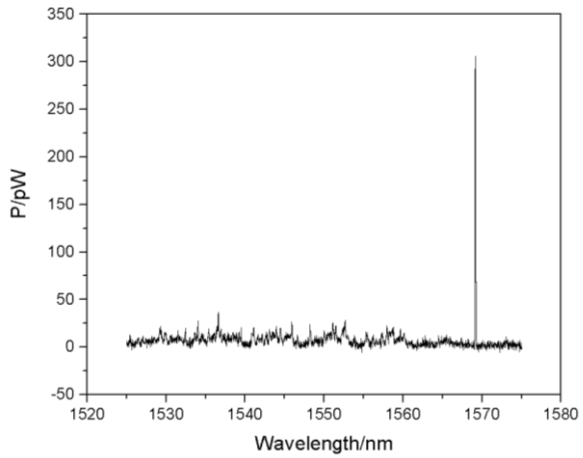

Figure 1. Microsphere lasing spectrum of Er^{3+}doped tellurite glass

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ODDERON MECHANISM FOR TRANSVERSE SINGLE SPIN ASYMMETRY

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In high energy collisions of polarized particles (i.e. their spin is aligned in a particular way), the existence of a preferred direction (i.e. that of the spin) can lead to an asymmetric distribution of the final state (produced) particles with respect to this direction. This phenomenon is known as transverse single spin asymmetry and is represented in Fig. 1. By considering collisions of quarks and nuclei, and while working in an effective theory of quantum chromodynamics, known as color glass condensate, the authors of [1] introduced a new mechanism for generating this asymmetry, known as the odderon mechanism. This mechanism can simplistically be described as an exchange of three gluons in colorless configuration. In our work [2], we refined their calculation by considering it at the level of hadrons (collisions of hadrons and nuclei) instead of free quarks and we found that (after some reasonable approximations) the odderon mechanism in fact vanishes in contradiction to the previous results.

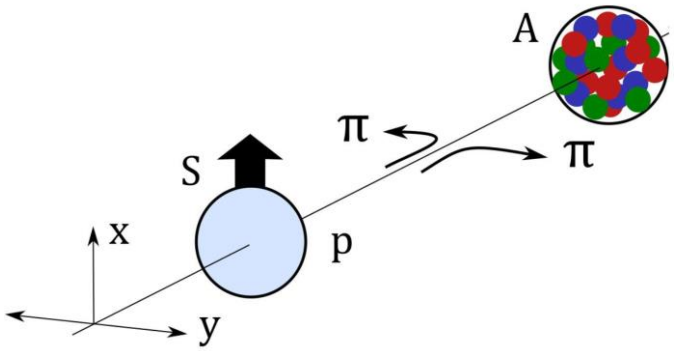

Figure 1. Transverse single spin asymmetry. Picture author: Dr. Sanjin Benić.

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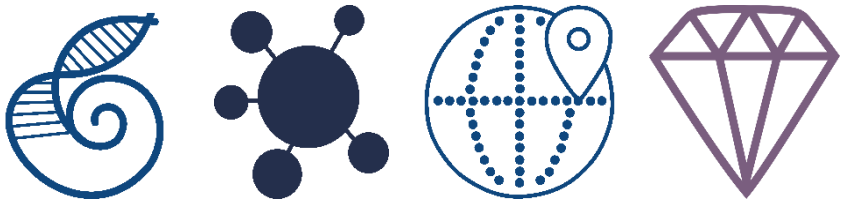

POSTER PRESENTATIONS

WNT PATHWAY IN MYELOPROLIFERATIVE NEOPLASMS

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Myeloproliferative neoplasms (MPN) include chronic myeloid leukemia if the person is positive for the BCR ABL mutation and essential thrombocythemia (ET), myelofibrosis (MF), polycythemia vera (PV) if the person is not positive for the BCR ABL mutation [1]. During the development of the disease, there is an abnormal growth of one or more lines of hematopoietic cells. Myelofibrosis is caused by mutation of the hematopoietic stem cell and is characterized by increased proliferation of myeloid cells with strong cytokine activity, which during early development leads to scarring of the bone marrow (myelofibrosis (MF)) [2] The role of the canonical Wnt signaling pathway in MPN is not fully defined, but current findings indicate that this pathway is activated in MPN patients. It has been proven immunohistochemically that in the megakaryocytes of patients with PMF, there is a lower expression of β-catenin compared to PRV and ET [3]. It was also shown that patients with PMF have a higher expression of β-catenin in vascular endothelial cells compared to PRV, ET and control [4]. A large number of mutations found in tumors affect a smaller number of complementary signaling pathways that regulate cell proliferation and survival. Accumulation of damage to various oncogenes and tumor suppressor genes in certain regulatory pathways leads to weaker control of cell growth and cancer formation [5].

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DETERMINING UNDERLYING GENETIC PREDISPOSITION OF THE HOST AS A DISCOVERY TOOL FOR RISK FACTORS IN COVID-19 PANDEMIC

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This study aimed to identify host genetic factors that could influence susceptibility to SARS-CoV-2 infection and severity of COVID-19 symptoms. Whole exome sequencing was performed on DNA isolated from blood samples of 192 COVID-19 patients. High-quality single nucleotide polymorphisms (SNPs) were identified [1] and functionally annotated [2, 3], and the association between SNPs and patient's symptom severity was checked [4]. 89 SNPs with a proven relationship to human health were found to have a significant association with symptom severity (p-value < 0.05), including SNP rs3153, which has previously been associated with increased mortality risk in severe COVID-19 cases [5]. These results suggest that host genetic factors play a role in determining the severity of COVID-19 symptoms and could be used to identify high-risk individuals.

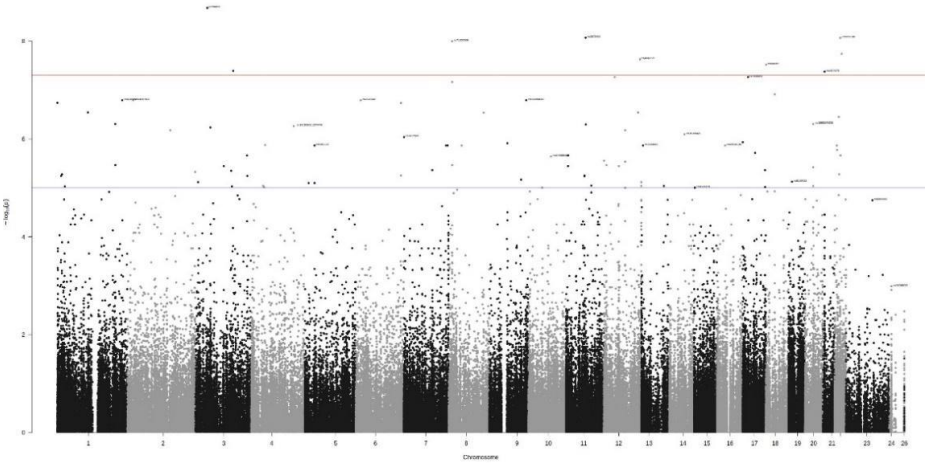

Figure 1. Manhattan plot of SNPs associated with COVID-19 symptom severity.

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DISTRIBUTION OF THE EUROPEAN FLAT OYSTER POPULATION IN THE BEAM TRAWL FISHING AREA OF THE WESTERN COAST OF THE ISTRIA PENINSULA FROM 2013 TILL 2021

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The European flat oyster (*Ostrea edulis*) is a commercially important species that is cultivated and harvested around the world, also in the Croatian part of the Adriatic Sea. The natural populations of this species are distributed along the Croatian part of the Adriatic coast, mainly in the subtidal zone. In the last decade, the Northern Adriatic Sea has emerged as an important fishing ground for this species, where oyster beds were abundant in shallow offshore areas with depths up to 35 meters. With Croatia's accession to the EU, the market for bivalves, including oysters, was expanded, and oyster harvesting increased from 2013 to 2015, reaching a maximum of 513 tons. However, since then, a decrease in landings has been observed, with a minimum of 15 tons in 2020 and 18 tons in 2021 [1]. Although exploitation could be the main cause of the population decline of *O. edulis*, other environmental factors such as increasing temperature and disease cannot be excluded. To assess the past and current state of the oyster population in the Northern Adriatic Sea, we applied three approaches: analysis of available historical data; analysis of internal and external databases; and a targeted scientific study of the current distribution of *O. edulis*. In this review, we used data from several databases to show the distribution of *O. edulis* in the period from 2013 to 2021, from which spatiotemporal changes in the abundance of *O. edulis* in the Northern Adriatic Sea can be seen. These results will be incorporated in the study that will be a scientific baseline for future spatial-temporal regulation of the fisheries in this area and to determine the potential for restoring oyster beds in the Northern Adriatic.

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STABILITY OF THE FRESHWATER NETWORK ECOSYSTEM DESPITE SEASONAL AND DOWNSTREAM CHANGES IN ENVIROMENTAL CONDITIONS AND DIVERSITY OF MICROBIAL COMMUNITIES

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Freshwater network ecosystems consist of interconnected lotic and lentic habitats within the same catchment area. The hydrologic and biogeochemical changes that occur during runoff in lotic systems significantly affect the succession of microbial communities in these systems [1]. Similarly, surface runoff from lotic systems has a significant impact on the environmental conditions and diversity of microbial communities in lentic systems [1]. Therefore, hydrology, system location, and local environmental conditions, along with community assembly processes [2], are the most important factors affecting microbial community formation in an interconnected freshwater network ecosystem. Using Plitvice Lakes as an example, we studied changes in environmental conditions and microbial communities (bacteria and fungi) that occur with runoff. Water samples from tributaries, interlake streams, and the Korana River were collected in three different seasons (spring, summer and autumn). Physio-chemical parameters were measured *in situ* (temperature and dissolved oxygen concentration) and subsequently from filtered water samples (DOC, Ca^{2+}, NO_3^- and Cl^- concentrations). The microbial communities of the water samples were characterized by amplicon sequencing of bacterial 16S rRNA and fungal ITS2 genes. All statistical analysis was performed using R software (R Core Team, 2021). The obtained results showed differences among three stream types and three different seasons, both in environmental conditions and diversity of microbial communities. They also showed seasonal differences in the bacterial community assembly processes, while fungal community assembly was not dominated by any single process. Despite the microbial diversity among different stream types and seasons, we proved the stability of the Plitvice lakes by determining the core microbiome, which accounted for the majority of the microbial communities in all stream types and seasons.

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CORRELATION BETWEEN THE SEX HORMONE RECEPTORS EXPRESSION AND DEMOGRAPHIC PARAMETERS IN HNSCC PATIENTS

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Head and neck squamous cell carcinoma (HNSCC) is the sixth most common cancer globally and has a high mortality rate since it is usually diagnosed in advanced stages [1]. Except for the well-known risk factors such as tobacco and/or alcohol consumption and HPV infection, the gender-specific risk for HNSCC development points to the endocrine microenvironment as another risk factor. In other words, the relative risk for HNSCC development is up to five times higher in males, suggesting either the existence of specific risk factors that affect only males or that females have defensive hormonal and metabolic features as a response to common risk factors [1]. Since some recent studies showed that androgens are significantly associated with poor patient prognosis, we wanted to correlate the sex hormone receptors expression in HNSCC tissue samples with the patient's age, gender, and primary tumor site. To determine the expression of nuclear (*AR*, *ESR1*, *ESR2* and *PGR*) and membrane androgen (*SLC39A9*, *OXER1* and *CACNA1C*), estrogen (*GPER1* and *SCN2A*), and progesterone (*PAQR5*, *PAQR6*, *PAQR7*, *PAQR8*, *PAQR9*, *PGRMC1* and *PGRMC2*) receptors in HNSCC, using the qPCR method, 73 tissue samples of primary HNSCC tumors, 26 metastatic lymph nodes and 22 healthy controls were used. Our results have shown that the mean age at the time of diagnosis was 65 years. Patients older than the median group age have higher expression of the *SCN2A* gene. Furthermore, 79,8% of patients were men, and 20,2% were women. The *ESR1* has a lower expression level in women, while expression levels of membrane estrogen receptor *SCN2A* and progesterone receptor *PAQR9* were significantly higher in women. Considering the categorization of head and neck tumors, the largest number of samples belong to oral cavity tumors (33), followed by tumors of the larynx (18), and then the oropharynx (8), hypopharynx (7) and the nasal cavity and paranasal sinuses (7). Interestingly, for both *OXER1* and *PGR* isoform B genes, lower expression in the larynx compared to the metastatic lymph nodes and oral cavity tissue samples was determined.

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CONCENTRATION AND QUALITY OF RNA AND microRNA ISOLATED FROM FORMALIN-FIXED PARAFFIN-EMBEDDED TISSUE SAMPLES OF PATIENTS DIAGNOSED WITH COLORECTAL CANCER OR ADENOMA

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Formalin-fixed paraffin-embedded (FFPE) tissue samples provide a wealth of information for cancer research. Isolation of RNAs from those samples is technically challenging due to RNA degradation during the fixation process and tissue storage [1]. MicroRNAs (miRNAs) are smaller and have higher stability than other RNA transcripts and can be easily isolated from FFPE tissue samples [2]. In this study we assessed the quality and integrity of the total RNA and miRNA isolated from FFPE tissue samples to determine whether they are suitable for further molecular biology assays. RNA and miRNA were isolated from FFPE tissue samples of 44 patients diagnosed with colorectal cancer or adenoma using RNeasy FFPE Kit (Qiagen) and miRNeasy FFPE Kit (Qiagen). Concentration of RNA and miRNA was determined using the DS-11 spectrophotometer (DeNovix). Quality of the samples was assessed using the RNA Integrity Number (RIN), percentage of RNA fragments less than 200 nucleotides in size and percentage of miRNA from the total small RNA using Bioanalyzer 2100 (Agilent). Concentration of RNA was 511.90 ng/µL with the range 85.52 - 1882.46 ng/µL, and miRNA 568.30 ng/µL with the range 15.33 - 2221.62 ng/µL. RINs indicate the integrity of the total RNA on a scale from 1 to 10. Mean RIN value was 2.17 ± 0.46 for 43 samples, as one sample had to be excluded due to its poor quality. Median percentage of RNA fragments less than 200 nucleotides was 41.5% with the range 14 - 96%. Median percentage of isolated miRNA from the total small RNAs was 29.5% with the range 10 - 80%. In conclusion, out of 44 analyzed FFPE tissue samples, 39 were suitable for further qPCR assays, while only 5 RNA isolates and 2 miRNA isolates do not satisfy the quantity/quality criteria for further gene expression studies.

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ANTIFUNGAL ACTIVITY OF SELENIUM NANOPARTICLES MODIFIED WITH POLYPHENOLIC-RICH OLIVE POMACE EXTRACT

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Antifungal activity of selenium nanoparticles (SeNPs) has been reported previously [1,2]. In this study, synthetic coatings and polyphenols derived from olive pomace extract (OPE) were used in the synthesis of SeNPs, which antifungal activity was evaluated *in vitro*. Four different types of SeNPs were synthesized – polyvinylpyrrolidone stabilized (PVP SeNPs), Polysorbate stabilized (PS SeNPs), polyvinylpyrrolidone stabilized and OPE modified (fPVP SeNPs) and Polysorbate stabilized and OPE modified SeNPs (fPS SeNPs). The antifungal activity was evaluated on common phytopathogenic fungi - *Botrytis cinerea, Macrophomina phaseolina, Sclerotinia sclerotiorum* and *Fusarium graminearum.* Control groups were non-treated fungi while sodium selenite was used as the reference compound known to exhibit antimicrobial activity. Taken together, the effects were dependent on the fungal species and the form of selenium applied. fPVP SeNPs showed stronger antifungal activity compared to PVP SeNPs against *Botrytis cinerea, Macrophomina phaseolina* and *Fusarium graminearum,* while fPS SeNPs showed improved antifungal activity compared to PS SeNPs against *Sclerotinia sclerotiorum and Fusarium graminearum*. The results indicate that surface modification using OPE can enhance the antifungal activity of SeNPs. In addition, this study provides new evidence of the effectiveness and usage of possible new “green pesticides'' in agricultural production.

ACKNOWLEDGMENTS

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BIFLAVONOIDS PROFILING IN DIFFERENT TISSUES OF GINKGO (*Ginkgo biloba* L.)

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Flavonoids are the best-studied group of specialized plant metabolites important for a wide range of plant interactions with the environment. After many years of science focusing on the monomeric forms of flavonoids, researched have been shifted to better understanding of the less studied dimeric forms, biflavonoids [1]. Structurally, biflavonoids are polyphenolic compounds consisting of two identical or non-identical flavone-flavonoid units linked in a symmetrical or asymmetrical manner by an alkyl or alkoxy linker of different lengths. They are restricted to certain species in the plant kingdom and one of the plants rich in biflavonoids is ginkgo (*Ginkgo biloba* L.) [2,3]. Although ginkgo is a well-known medicinal plant, the tissue-specific distribution of biflavonoids in ginkgo has not yet been elucidated. Therefore, the aim of our study was to develop a HPLC-DAD method for the simultaneous determination of five biflavonoids (amentoflavone, bilobetin, ginkgetin, isoginkgetin, and sciadopitysin) in 10 different ginkgo tissue types. We measured the total content of polyphenols and flavonoids using spectrophotometric methods as well. We detected biflavonoids only in the plant parts that are in direct contact with the environment (leaves - petioles and leaf blades, tree and branch bark, buds, seed stalks, and sarcotesta), which may indicate their role in plant-environment interaction. The highest content of biflavonoids was found in leaves (7090 ± 35.75 µg/g dw), with sciadopitysin (2398 ± 727.40 µg/g dw) being the predominant compound. In contrast, in tree bark and twigs, the most abundant biflavonoid was amentoflavone (63.34 ± 4.57 µg/g dw and 75.70 ± 6.80, respectively) [4]. Our results showed a different distribution of methylated biflavonoids though the tissues when compared to their unmethylated form, which might indicate their different roles in plants, but their exact biological functions remain to be explored.

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DISTRIBUTION OF SELECTED METALS/METALLOIDS AMONG DIFFERENTLY NEGATIVELY CHARGED CYTOSOLIC METAL-BINDING BIOMOLECULES IN THE DIGESTIVE GLAND OF FRESHWATER MUSSELS

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Cytosol is a metabolically active part of the cell that contains metalloproteins with isoelectric point (pI) values clustered between 4.0 and 6.0 [1]. Despite their responsibility for metabolic processes [2], metalloprotein characteristics (mass, charge, etc.) are poorly understood in many organisms, including mussel species. Therefore, the aim of this study was to analyse the distribution of 14 selected metals/metalloids among differently charged metal-binding biomolecules in the digestive gland cytosol of the mussel species *Unio crassus* (Philipson, 1788) using anion-exchange high-pressure liquid chromatography (AEX-HPLC) and mass spectrometric analysis (ICP-MS). Protein separation using AEX-HPLC was performed with a linear salt gradient (0-500 mM NH_4OAc; 20 minutes) in 10 mM Tris buffer (pH 7.4). Metal-binding biomolecules with lower pI values tend to interact more strongly with AEX resins, requiring higher salt concentrations for elution [2]. In addition, the AEX- profiles of five protein standards with known pI values (alcohol dehydrogenase, carbonic anhydrase, metallothioneins 1 and 2, superoxide dismutase) were analysed. The results showed that the majority of biomolecules binding the elements Ag, As, Bi, Cd, Cs, Cu, Fe, Pb, Se, and Zn had elution times similar to those of the analysed protein standards (first 10 minutes; pI higher or ≈ 4). Only a few elements (Ag, Co, Cd, Pb, and Mo) were bound to cytosolic biomolecules at the end of the salt gradient (15-20 min; >375 mM NH_4OAc), indicating the presence of more acidic proteins, i.e., proteins with very low pI values. Several elements (As, Co, Cs, Cu, Fe, Mn, Pb, Se, Zn) were eluted in the void volume indicating the presence of basic metal-binding proteins in the mussel digestive gland cytosol. Some elements (Ag, Co, and Mo; Cd and Pb; Mo and Zn; Ag, Cu, and Cd) had overlapping peaks, suggesting that they are bound to the cytosolic biomolecules of the same charge in the digestive glands of this bivalve species. Further application of additional chromatographic separation and mass spectrometry techniques is needed to confirm the identity of these cytosolic biomolecules.

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MORPHOLOGICAL CHARACTERIZATION OF NORWAY LOBSTER *Nephrops norvegicus* (LINNAEUS, 1758) POPULATIONS IN THE ADRIATIC SEA

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Norway lobster, *Nephrops norvegicus*, is one of the most valuable commercial crustacean species in the Mediterranean trawl and creel fishery, with most stocks showing a declining trend and overfished status in the last decade [1]. Although knowledge of important parameters for stock assessment is well established [2], research on morphology is still sparse, despite its influence on foraging, behaviour, and other life history traits. The present study focuses on the morphological characteristics of Norway lobster in the Adriatic Sea with the aim of determining the size at morphometric maturity, the shape of the cephalothorax and the median tooth of populations inhabiting channels and open sea areas. The average size at the onset of morphometric maturity was 3.9 cm in individuals from the open sea, while it was 4.3 cm in lobsters from channel areas. On average, individuals from the open sea had a more slender and elongated shape of the cephalothorax than those from channels, while the median tooth crown of individuals from the open sea displayed an arrow-shaped form that differed from the broader crown of lobsters from channel areas. Based on morphological characteristics, the results suggest that selection on phenotypic traits may be related to variations in feeding niches and to an adaptive response to gear selectivity in the channels and the open sea. Therefore, these findings should be taken into account in the future management of the *Nephrops* fishery in the Adriatic Sea.

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PRIMARY PRODUCTION IN THE ADRIATIC SEA – A REVIEW WITH EMPHASIS ON NEW DATA OBTAINED AT LASTOVO ISLAND

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The primary production (PP) supports the marine food web, and affects global biogeochemical cycles [1]. Therefore, measuring and monitoring PP is of huge importance for tracking ecosystem responses to the anthropogenic-driven climate change. PP can be measured in-situ, ^{14}C technique being widely used [2], or it can be estimated by satellite remote sensing [1], and different models [3,4]. Remote sensing and modeling estimate global PP at large spatial and temporal scale, but they have their own restrictions [4] and require in-situ data for algorithm validation [3]. As a result, in-situ time-series data is of significant importance for PP modeling in world oceans [3]. Continuous PP in-situ measurements using ^{14}C technique are done since April 1962 at two stations in the Central Adriatic Sea: coastal Kaštela Bay and open sea Stončica station. Time-series data was corrected for overestimates of daily production using non-linear production model, and five decadal regimes were observed: 1962-1979 (118 mg C m^{-2}), 1979-1997 (300 mg C m^{-2}), 1997-2008 (128 mg C m^{-2}), 2008-2013 (251 mg C m^{-2}), and the last one is ongoing since 2013 (154 mg C m^{-2}) with a trend of PP decrease [3]. Overall, models reveal global decrease of PP in Mediterranean. However, there is a trend of increase in Adriatic Sea [4], which may be due to enhanced anthropogenic nutrient input, and climate change effects. We conducted ^{14}C in-situ PP measurements at Lastovo and Korčula Islands during the ISLAND project field experiment in June 2022 (i.e., during water layer thermal stratification). Daily integrated NPP was calculated: 185.50 mg C m^{-2} d^{-1} at station Maslovnjak (north of Lastovo Island), 190.04 mg C m^{-2} d^{-1} at station Struga (south of Lastovo Island), and 80.77 mg C m^{-2} d^{-1} at station Prižba (Korčula Island). More in-situ experiments are planned for the future in order to compare data points to satellite remote sensing data and to model algorithms for the future PP estimates in the Adriatic.

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INVESTIGATING THE N-GLYCOSYLATION OF IMMUNOGLOBULIN A IN TYPE 1 DIABETES

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N-glycosylation is a strictly regulated enzymatic reaction during which complex oligosaccharides are covalently attached to proteins, thus impacting their function [1]. One of such proteins is immunoglobulin A (IgA), a heavily glycosylated antibody which plays a key role in the immune system. Glycans modulate its various roles, including antigen binding and the antibody effector functions [2]. Despite its significance, N-glycosylation of IgA remains largely underexplored in autoimmune diseases, including type 1 diabetes (T1D). Former studies on IgA in T1D have focused mostly on its serum levels, suggesting a disruption of IgA catabolism [3]. In this study, we analyzed serum IgA N-glycosylation in 86 children at the onset and 63 of their healthy siblings, as well as in 90 adults with T1D and 90 healthy controls using a high-throughput UPLC approach. N-glycome was divided into 30 glycan groups from which 12 derived traits were calculated based on structural similarities. Our study identified IgA N-glycan traits characteristic of T1D and revealed differences in the N-glycosylation patterns of IgA between children at T1D onset and adults with T1D. In children, IgA N-glycoprofile remained mostly unchanged compared to their healthy siblings, with only one oligomannose N-glycan significantly increased. IgA N-glycome in adults exhibited a shift towards complex high-branched, trigalactosylated and trisialylated as well as oligomannosylated glycans, while the most prominent association with T1D was a decrease in total core fucosylation. These findings indicate a transition of IgA N-glycosylation in T1D toward patterns characteristic of total plasma proteins in various inflammatory conditions.

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CHARACTERIZATION OF PATIENT-DERIVED SARCOMA STEM CELLS

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Sarcomas are bone tumors of mesenchymal origin. They are characterized by a poor prognosis due to the development of chemoresistance and early metastases. Cancer stem cells (CSC), a small subpopulation of tumor cells are believed to play a major role in tumor spread, chemoresistance, metastasis, and disease recurrence. To understand better the mechanisms behind those properties, it is important to isolate and analyze CSC from patient samples. For that purpose, the biopsy specimen of Ewing's sarcoma is digested and plated to start parental cell culture. Sarcoma stem cells were selected and grown as tumor spheroids [1]. To characterize this type of cells, we performed a sphere formation assay to determine tumor initiation efficiency and measured telomerase activity to establish the mechanism of immortality. There is one more mechanism that enables cells to become immortal through alternative mechanisms of recombination pathways. We will perform a sphere growth inhibition assay during chemotherapy treatment to analyze their chemoresistance [2].

Tumor cells were isolated to obtain primary parental culture. The cells were grown in restrictive conditions using the serum-free medium in low attachment dishes and passed through 1sth generation of spheroids to select for CSC. We let the cells grow in the spheroids for 4 weeks with the addition of growth factors FGF and EGF twice a week [1]. We determined the level of telomerase expression as a feature of CSC using qPCR. To determine CSC chemoresistance we performed a sarcosphere inhibition assay. Cells were seeded in restrictive conditions to allow sphere formation. They were treated with drugs frequently used for chemotherapy of sarcomas such as doxorubicin, cisplatin, and methotrexate. Cell viability was measured by MTT assay [2].

Spheroid formation was observed using the Laser scanning confocal microscope Leica SP8 X twice a week. After a month they reached a diameter of 75 µm and RNA was isolated for qPCR. The telomerase activity was lower compared to the level before the test and both samples were lower compared to positive control HeLa cells but consistent with the negative control U2OS cells. The results from the sphere growth inhibition assay will be compared to negative untreated control and to adherent patient-derived cells also treated with chemotherapeutics.

Primary cells isolated from a patient with Ewing's sarcoma possess stem cell properties such as the ability to form spheres. Their spheroid growth does not depend on telomerase activity.

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MICROEVOLUTION OF A MUMPS BASED RECOMBINANT VIRUS WITH HCV GENES DURING PASSAGING IN VERO CELLS

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Hepatitis C virus (*Hepacivirus C*, HCV) infection represents a global health problem, estimates for 2019 show that 1.5 million people were newly infected with HCV [1]. The development of a prophylactic vaccine is necessary to control the transmission of the virus [2]. An ideal immunization strategy should be able to elicit protective neutralizing antibodies against different viral strains, as well as fast and sustained cellular responses [3], which is a hallmark of most recombinant vector vaccines based on live attenuated viral strains. One of the approaches in the development of HCV vaccines is the production of recombinant viruses expressing the main neutralization antigens of HCV, envelope (E) proteins E1 and E2.

We have produced a recombinant mumps virus, vCE1E2-HCV-MRV2, containing HCV proteins core (C), E1 and E2. The virus was based on the consensus sequence of attenuated mumps vaccine strain L-Zagreb. The aim of this research was to analyze genetic stability of vCE1E2-HCV-MRV2 during *in vitro* passaging in a vaccine production cell line. The stability of viral populations was determined in supernatants of infected cells from the 5th and 10th passage using next-generation sequencing.

Viral population in master seed stock was quite homogeneous. However, serial passaging of the virus led to removal of large segments of inserted genes from the viral genome in some samples, which was also evident on the protein level. There was an increase in the diversity of viral populations during early passages; afterwards, the level of population heterogeneity was unchanged. A number of heterogeneous positions was found in inserted genes, as well as few different nonsense substitutions that were detected in viral minority variants.

The results presented here strengthen the need of close monitoring of genomic stability during the production of recombinant viruses, especially the ones intended for use in vaccine strategies.

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EFFECTS OF S-ADENOSYLHOMOCYSTEINE-HYDROLASE DOWN-REGULATION ON WNT SIGNALING PATHWAY IN SW480 CELLS

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S-adenosylhomocysteine hydrolase (AHCY) is an enzyme that catalyzes the hydrolysis of S-adenosylhomocysteine (SAH) to adenosine and homocysteine. SAH is a byproduct of S-adenosyl methionine (SAM) metabolism and its accumulation due to lack of AHCY activity inhibits numerous SAM-dependent methyltransferases (MTs) thereby disrupting the balance of cellular methylation reactions. Studies of various tumor tissues show decreased AHCY expression in prostate, lung, and colon cancer. [1] Downregulation of AHCY also causes increased levels of SAH, which in turn is associated with increased cell proliferation, migration, and invasion, possibly due to disruption of methylation status and altered expression of key genetic factors that control these vital cellular processes. [2] Our current research focuses on analyzing changes in cell transcriptome due to the lack of AHCY expression with the goal of better understanding the various molecular roles of AHCY in systems such as the SW480 colorectal cancer cell line. Thus we performed deep sequencing of SW480 mRNA (RNAseq) and differential expression analysis. Subsequently, RNAseq data were analyzed using Ingenuity Pathway Analysis (IPA) software. Fifteen differentially expressed networks were identified, and interestingly, we found a predicted effect of AHCY down-regulation on the expression of the *LEF1* gene. LEF1 is a transcription factor and member of the Wnt signaling pathway that promotes cell proliferation and survival and is known to be activated in many cancers. [3] Altered methylation patterns as a result of AHCY aberrant activity are associated with changes in gene expression that may affect LEF1 protein levels and their function. Investigation of this relationship may help elucidate the molecular mechanisms underlying the effect of AHCY on cancer cell behavior. Western blot analysis of LEF1 protein expression confirmed our transcriptomic data predictions and revealed significantly increased LEF1 protein in AHCY-deficient cells, providing a novel link between AHCY and cancer cell phenotype. Understanding the molecular basis of the interplay between these two factors may help researchers gain new insights into novel potential therapeutic targets for cancer treatment.

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PARTY IN THE DRY RIVERBED! HOW SPIDERS USE DIFFERENT INTERMITTENT RIVER HABITATS

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Dry riverbeds are seasonally occurring habitats in most intermittent rivers, yet terrestrial invertebrates are still rarely considered in their ecological status assessment. Spiders play a vital role in the ecological dynamics of riparian habitats [1] and are among dominant taxa in dry riverbed communities alongside ants and beetles [2, 3]. This study aimed to identify the dispersal patterns of spiders during the terrestrial phase of the intermittent karst river Krčić. The study was conducted in July 2021 using cross-vane window traps set up in the dry riverbed and riparian habitats to examine spider dispersal by air, while ground-dwelling spiders were sampled by pitfall traps in the dry riverbed, riparian, and upland karst habitats. Wind speed and directionality were continuously recorded using wind loggers. The abundance of ground-dwelling spiders was significantly higher in the dry riverbed and riparian habitats than in the upland karst habitat. We assume that the higher moisture in the riverbed compared to the surrounding habitat was attractive to spiders, either directly by fulfilling their humidity requirements, or indirectly by sustaining high prey availability. Taxa richness and diversity indices of spiders collected by both trap types did not differ significantly between studied habitats. There was a positive correlation between wind speed and the abundance of spiders caught in window traps, which implies that spiders colonize dry riverbeds as a part of aerial plankton. Daily average windspeed was considered optimal for spider ballooning behavior [4]. The results show that dry riverbeds, although frequently disregarded in intermittent river ecology, contribute substantially to the overall biodiversity.

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SIRTUIN 3 PROTEIN IN SEX-SPECIFIC MAINTENANCE OF ENERGY HOMEOSTASIS DURING AGING

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Aging is associated with increased inflammation and changes in mitochondrial biogenesis that promote the development of age-related diseases [1]. Impaired mitochondrial function leads to an increase in the concentration of reactive oxygen species and oxidative stress [2]. Sirtuin 3 (Sirt3), the major mitochondrial deacetylase that regulates numerous metabolic processes, has been shown to be an important anti-aging molecule and regulator in many age-related diseases [3]. However, there is limited information on its role in the context of sex differences in energy homeostasis. To test our hypothesis that the age-dependent role of Sirt3 in maintenance of energy homeostasis is sex-dependent both *in vitro* and *in vivo*, we measured proliferative, metabolic, and mitochondrial parameters in young and old Sirt3 wild-type (WT) and knockout (KO) mice and in Sirt3 WT and KO mouse embryonic fibroblasts (MEFs). Survival analysis of mice and proliferation analysis of MEFs indicated that males are more dependent on the protective role of Sirt3. We analysed the percentage of cells in S phase and used a senescence probe for flow cytometry to confirm the induction of age-related changes in MEFs. In addition, we analysed the weight and biochemical parameters of the mice, mitochondrial respiration and differences in metabolites in both mice and MEFs. The successful completion of this study will contribute to the understanding of the physiological significance of Sirt3 in the context of sex-specific differences during aging, which will provide a basis for the future development of sex-specific drugs and the identification of relevant therapeutic targets for the treatment of age-related diseases.

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THE MUTATIONAL PROFILE OF GENES INVOLVED IN TUMORIGENESIS PRESENTS THE BEST PREDICTION OF CELL-OF-ORIGIN USING MACHINE-LEARNING METHODS

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Multiple cell-of-origin (COO) classifiers have been developed on a wide range of molecular methods utilizing various genomic, transcriptomic and epigenomic features for COO prediction. The model for predicting the cell-of-origin using mutations detected by whole-genome sequencing [1] is based on the fact that chromatin structure, governed by processes such as histone modifications, greatly influences the rate at which background (passenger) mutations accumulate in a cell type-specific manner. Since whole-exome sequencing can provide valuable gene-specific information and is important for the diagnosis and treatment of unknown cell-of-origins, we aim to develop a model that predicts the COO by utilizing mutational profiles of genes and chromatin states across those genes. We analyzed a publicly available liver cancer cohort from the International Cancer Genome Consortium. ChIP-Seq data for six histone modifications (H3K27ac, H3K27me3, H3K36me3, H3K4me1, H3K4me3, H3K9me3) and input control for multiple normal tissues were downloaded from the Roadmap Epigenomics project. The developed multiple linear regression model with 10-fold cross-validation with the highest variance of aggregated mutations across genes explained by the epigenome of normal tissues is then chosen as the predicted COO for a specific cancer type. We applied several filtering strategies to identify the most informative set of genes and found that restricting the analysis to protein-coding genes and genes previously known to be involved in tumorigenesis increased the total variance explained by the model by 10% and 25%, respectively, and allowed the identification of hepatocytes as the correct cell-of-origin of liver cancer. We tested and validated our preliminary model on an unrelated cancer type. Our results show that we can use the cell's epigenome and cancer's gene mutation profile to predict the cell-of-origin.

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BIOLOGICAL REMOVAL OF PHENOL, CYANIDE AND THIOCYANATE FROM INDUSTRIAL WASTEWATER

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Biodegradation is an efficient, cost-effective and sustainable method for removal of phenols, cyanides, and thiocyanates from wastewater. Concentrations of phenols, cyanides and thiocyanates in industrial wastewaters range from 2.8-6800 mgL^{-1}, 0.1-10 mgL^{-1} and 500-4000 mgL^{-1}, respectively [1-3]. Phenolic compounds are the most common organic pollutants of industrial wastewaters, which are biologically recalcitrant. Variety of microorganisms have been capable of biodegradation of phenolic compounds, such as bacteria *Pseudomonas* sp., *Acinetobacter* sp., *Bacillus* sp., as well as algae *Scenedesmus* sp. and *Chlorella* sp., yeasts *Candida* sp. and *Schizoblastosporion* sp., and fungus *Ascomycetous* sp., *Aspergillus* sp., *Debaryomyces* sp. and *Basidiomycetes* sp. [1]. Cyanide is a carbon-nitrogen radical, toxic at high levels in all forms, among which hydrogen cyanide is the deadliest. Fungal species capable of cyanide degradation are *Fusarium* sp., while the most common bacterial species are *Pseudomonas* sp. [2]. Thiocyanate is one of the most important cyanide complex species, formed in the reaction of cyanide, sulfide, and thiosulfate, and consists of carbon, nitrogen, sulfur, and other elements. Due to its toxicity and chemical stability, it is difficult to degrade, causing harm to the ecosystem. The dominant phyla of thiocyanate degrading consortium were found to be Proteobacteria, Bacteroidetes, Patescibacteria and Armatimonadates, and at the genus level *Thiobacillus* was dominant in the consortium [3]. Degradation products of phenols, cyanides and thiocyanates are CO_2, H_2O and innocuous products; HCO_3^- and NH_4^+; and SO_4^{2-}, NH_4^+ and CO_2, respectively [1-3].

ACKNOWLEDGMENTS

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THE SATELLITOME OF THE CONFUSED FLOUR BEETLE *Tribolium confusum:* GENOMIC AND CYTOGENETIC ASPECTS

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The confused flour beetle *Tribolium confusum* is a major stored products pest which is spread worldwide. It is also present in laboratory research as it is an excellent model for population and genetic studies. The genome of the beetle *T. confusum* contains large blocks of heterochromatin, which makes it suitable for studying non-coding DNA sequences. The most intriguing class of non-coding DNAs are satellite DNAs (satDNAs), tandemly repeated sequences primarily associated with the centromeric and telomeric parts of eukaryotic chromosomes. One major satDNA family dominates the genome of the confused flour beetle amounting to the total of 40% of its genomic sequence [1]. The aim of this work was to investigate whether there are other satellite DNAs in the genome of *T. confusum* besides the major satDNA family.

Using two different types of high-throughput sequencing on the Illumina and PacBio platforms and the bioinformatic pipeline TAREAN [2], we characterized for the first time 16 new satDNAs in the genome of *T. confusum* defining its satellitome. Considering their abundance, and compared to the major satDNA, which is a high-copy-number satellite, two newly discovered satDNAs are categorized as moderate-copy and the remaining 14 as low-copy-number satellites. Chromosomal location and organization of the satDNA representatives for each group were determined by fluorescence *in situ* hybridization (FISH) on metaphase chromosome spreads (2n=18) and on the extended DNA fibers. The different distribution patterns of the studied satDNAs correspond to their genomic abundance, with low-copy-number satellites being chromosome-specific. We found that one of the chromosome-specific low-copy-number satellites is also present in the genomes of other *Tribolium* species, specifically *T. castaneum, T. freemani and T. madens*. By exploring the different satDNA families that make up the genome of *T. confusum*, we are getting closer to understanding the genome of this important pest, but also to understanding the evolution of satDNAs within the genus *Tribolium*.

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THE POTENTIAL PROTECTIVE ROLE OF DEHYDROEPIANDROSTERONE AND ITS SULFATE IN THE GENETIC AND PHARMACOLOGICALLY INDUCED ANIMAL MODEL OF ALZHEIMER'S DISEASE

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Alzheimer's disease (AD) is the most prevalent form of dementia, accounting for 60-70% of all dementia cases. It is a progressive and incurable neurodegenerative disorder characterized by the amyloid beta (Aβ) peptide deposition in the amyloid plaques and accumulation of hyperphosphorylated tau protein in the neurofibrillary tangles [1]. It affects neuronal functioning and connectivity, resulting in a progressive loss of brain functions, with the cortex and hippocampus being primarily affected [2,3]. The current AD therapy is only effective in alleviating the symptoms, whereas ongoing research aims at discovering new disease-modifying treatment strategies. The neurosteroids dehydroepiandrosterone (DHEA) and its sulfate (DHEAS) have been studied for their neuroprotective potential in AD [4]. Although these steroid hormones are abundant in the human blood, they are also produced *de novo* in neurons and glial cells, where their concentration is 6-8 times higher in comparison to periphery [5].

In our research, we have utilized both genetic and pharmacologically induced mouse model of AD. The triple-transgenic AD (3xTg-AD) mouse is one of the most appropriate animal models of AD, displaying all main histopathological and behavioral features of AD, including age-dependent development of amyloid plaques, neurofibrillary tangles and progressive cognitive decline [6]. The 3xTg-AD mice and C57BL/6 control mice were chronically treated with DHEAS using subcutaneously intrascapulary implanted osmotic pumps. The pharmacologically induced AD model was established by intracerebroventriculary injecting the C57BL/6 mice with Aβ oligomers and chronically administered with DHEA via intraperitoneal injection. Various cognitive and behavioral tests were performed on both models and analyzed using Noldus EthoVision XT software. Upon completion of the treatments and behavioral testing, the mice were euthanized and their brains were harvested for further analysis.

Our results suggest that DHEA(S) could potentially serve as a protective agent against cognitive decline and other symptomatic presentations in mouse models of AD. Nevertheless, further validation of these results is necessary and it is imperative to extend our findings to include human blood samples to investigate potential therapeutic strategies of these neurosteroids in the future.

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HETEROLOGOUS EXPRESSION AND PURIFICATION OF TWO PROTEINS FROM THE RAS SUPERFAMILY OF SMALL GTPases

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Protein-protein interactions are vital for many cellular processes and their research allows us to understand these processes from a biochemical point of view. Since changes in the regulation of signaling pathways in the cell often lead to the development of various diseases, studying protein-protein interactions can help us better understand their origin, development and impact on human health.

Analysis of the cellular proteome in search for the interactors of dipeptidyl peptidase III (DPP III) by SILAC-MS revealed SH2D3C protein as a putative interactor of DPP III. SH2D3C acts as an adapter protein in signaling pathways involved in cell adhesion and migration, tissue organization, and regulation of the immune response [1]. SH2D3C contains Ras GEF-like C-terminal domain that resembles Ras GEF domains from the proteins that activate small GTPases from the Ras superfamily. SH2D3C binds two small GTPases, R-Ras and Rap1a, however, it does not show Ras GEF activity [2]. Our hypothesis is that binding of DPP III to SH2D3C could activate SH2D3C, therefore, we want to analyze potential Ras GEF activity of SH2D3C in the presence of DPP III.

For the purpose of testing the Ras GEF-activity of SH2D3C, two proteins from the Ras superfamily of small GTPases, R-Ras and Rap1a, were heterologously expressed in *E. coli* with HIS and GST tags and purified by affinity chromatography.

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IMPACT OF NON-THERMAL TECHNIQUES IN THE PROCESSING OF COFFEE SILVER SKIN (CS)

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The Sustainable Development Guidelines (SDG) encourage use of useful techniques in processes extractions such as Ultrasound-assisted extraction (UAE). Coffee silver skin (CS), as a waste, could be used in the production of new food products. The aim of this research was to isolate proteins and polyphenols using UAE from CS and spectrophotometrically determine their proportions [1]. Three parts of research have been proceeded: ultrasonic extraction, optimization UAE conditions for isolation of proteins and polyphenols from CS and analysis of the amino acid extract obtained under optimal UAE [2]. It is concluded that the highest yields of total polyphenols isolated from the CS using UAE were obtained by applying an amplitude of 75% and a time interval of 9 minutes. The most abundant amino acids in isolated proteins are defined as well. Based on the use of energy, it was obvious that UAE is a promising technology. This concurs with the proposed practice that when non-thermal technologies are analyzed from an environmental point of view, the first common denominator is use of electric energy for running the equipment, related to resource depletion. As expected, CS represents a nutritionally rich raw material with great potential [3]. Quantitative consideration on the environmentally friendly applicability of CS in mass production should be carried out to validate the entire process of developing new product from both economic and environmental aspects.

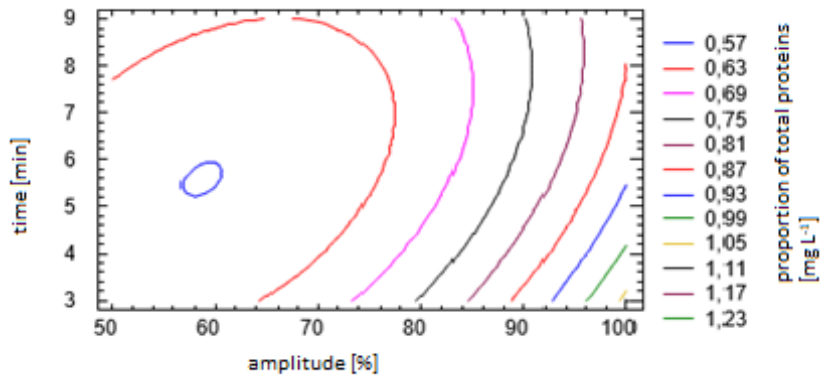

Figure 1. Contour plot of the response surface for the proportion of total proteins.

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SYNTHESIS OF UNNATURAL C-GLYCOSYL *α*-AMINO ACIDS DERIVED FROM D-GALACTOSE, D-RIBOSE, D-XYLOSE, AND L-SORBOSE

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Carbohydrate-derived non-proteinogenic amino acids (NPAAs) are widely used in scientific research, particularly in the fields of medicinal chemistry, catalyst design, and materials science. Despite developed methodologies, the majority of published data relates to amino acids with carbohydrate units placed at the side-chain, C-glycosyl *β*- or *γ*-amino acids, while examples of C-glycosyl α-amino acids, where carbohydrate units are directly attached to C*α* atom, remain scarce [1]. We anticipate that amino acids with bulky carbohydrate units directly attached to C*α* atom will have a significant impact on the stabilization of a particular secondary structure. Therefore, the aim of our research is to elucidate how the structure of C-glycosyl *α*-amino acids, including their stereochemistry, number, and distribution within the peptide sequence, determine the conformation of the peptide.

Two methodological approaches are used for the synthesis of C-glycosyl *α*-amino acids, that can be utilized as monomers in the synthesis of C-glycopeptides [2,3]. The first approach involves multicomponent reactions with carbohydrate aldehydes to form *α*-acyloxyamides, which can be further transformed into C-glycosyl *α*-amino acids (Figure 1A, left). The second approach involves photocatalyzed generation of C-glycosyl radicals from carbohydrate redox-active esters, followed by their addition to *α*-imino ester (Figure 1A, right). C-glycopeptides will be synthesized by Fmoc strategy solid-phase peptide synthesis. It can be assumed that peptides will adopt conformationally distinct secondary structures depending on the type and position of incorporated C-glycosyl amino acid. Finally, the role of structure, stereochemistry, and non-covalent interactions responsible for their stabilization will be determined.

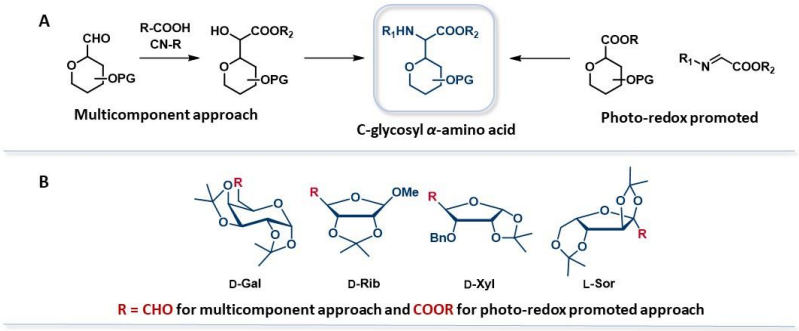

Figure 1. A) Methodologies anticipated for the synthesis of C-glycosyl *α*-amino acids, (B) C-glycosyl donors.

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INTERACTION OF LECTIN SAMBUCUS NIGRA WITH SIALYLATED TRISACCHARIDES

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Protein-carbohydrate interactions play an essential role in numerous biological processes such as development, infection, immunology, and carcinogenesis [1,2]. However, since these interactions are relatively weak, their detection is rather challenging. To approach this topic, we used constant current chronopotentiometric stripping (CPS). CPS is a label−free structure−sensitive analysis that can be used to study structural changes not only of free proteins and peptides but also those in complexes with binding ligands [3]. In this work, we were able to detect and study the interactions of lectin Sambucus nigra (type SNA−1) with sialylated trisaccharides (weaker binding α(2−3)-sialyllactose (3SL) and stronger binding α(2−6)-sialyllactose (6SL)), in the presence of an osmolyte. We show that the addition of an osmolyte excess can significantly improve the reproducibility of experiments and that CPS analysis is able to reliably distinguish between individual complexes.

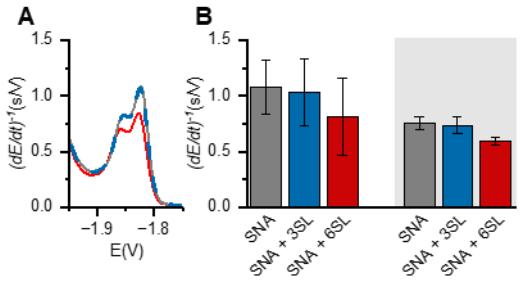

Figure 1. A. Chronopotentiograms and **B.** CPS peak heights of free SNA−1 (grey) and that incubated with a 3SL (blue), 6SL (red) in the absence (white background)/presence of osmolyte (gray background).

ACKNOWLEDGMENTS

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THE APPLICATION OF WASTE EGGSHELL DERIVED CALCIUM OXIDE IN BIODIESEL SYNTHESIS

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Poultry egg consumption is quite frequent worldwide which consequently causes large amounts of eggshell waste, approximately 8.58 million tons per year. Due to high disposal costs, recycling of the waste eggshells into an enviromentally-friendly catalyst is a potential solution [1,2]. Eggshell consists mostly of calcium carbonate ($CaCO_3$), which is transformed into calcium oxide (CaO) through the calcination process and used as a heterogeneous catalyst [1]. Such catalyst is suitable for the industrial production of biodiesel because of its easy separation from the reaction mixture and reusability, reducing the process costs. Biodiesel itself is a renewable energy source and is considered an alternative fuel to commercial diesel. It is primarily obtained via transesterification reaction, from vegetable oils or fats and an alcohol, in the presence of a catalyst. The use of a heterogeneous catalyst originating from waste eggshells, as well as waste cooking oil as feedstock, further contributes to the renewability of the entire biodiesel synthesis process and the recovery of waste materials [3]. This study compares the influence of CaO obtained by calcination at 900 °C from eggshell and commercial CaO on the conversion of waste cooking oil into fatty acid methyl esters (biodiesel). The reaction was carried out for 2 hours at 65 °C with 5 % catalyst by mass of oil. NMR analysis showed yields of 100 % for both catalysts.

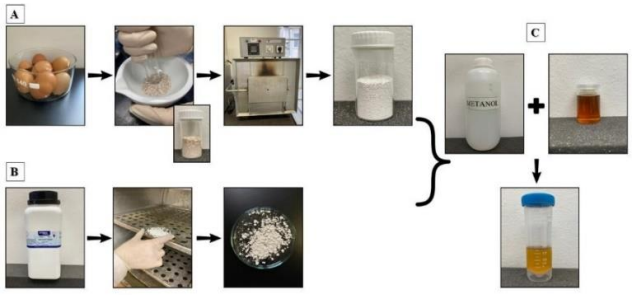

Figure 1. (A) preparation CaO from chicken eggshells; (B) drying commercial CaO; (C) the synthesis of biodiesel.

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ANTIOXIDANT AND ANTI-INFLAMMATORY ACTIVITY OF BIOCOMPATIBILE CYCLODEXTRIN-GLYCEROL BASED EXTRACTS OF SATUREJA MONTANA

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Winter savory (*Satureja montana* L.) is annual, medicinal, and aromatic plant from the Lamiaceae family. It is a plant which grows in sub-Mediterranean areas in dry, sunny, and rocky habitats [1]. In Mediterranean diet, *Satureja montana* is widely used for its anti-inflammatory, antibacterial, antifungal and antioxidant properties. In this work, antioxidant, anti-inflammatory and biocompatibility effects of glycerol-cyclodextrin based extracts of *S.montana* were investigated. The extracts were prepared using biocompatible solvents, such as glycerol and water with addition of 2-hydroxypropy-β-cyclodextrin. The free-radical-scavenging activity (RSA) of both extracts was assessed with the 2,2-diphenyl-1-pycrylhydrazyl (DPPH) method. The anti-inflammatory activity was investigated by using anti-lipoxygenase (anti-LOX) assays and the heat-induced ovalbumin coagulation method [2]. Biocompatibility effect was investigated by using MTT assay on the HaCaT cells [3]. The extracts (SMCD0; SMCD015; SMCD020; SMCD034) showed strong antioxidant activity (2.07 ± 0.05 µg/mL, 1.69 ± 0.31 µg/mL, 1.4 ± 0.14 µg/mL, 1.22 ± 0 µg/mL, respectively) and were significant greater compered to positive control (butylated hydroxyanisole (BHA) (8.32 ± 0.11 µg/mL). In both anti-inflammatories performed assays, heat-induced ovalbumin and LOX inhibition assay, the extract SMCD020 (26.98 ± 3.81 µg/mL; 2.56 ± 0.19 µg/mL, respectively) showed the best activity between extracts and it was significantly greater compered to positive control (diclofenac: 248.81 ± 8.27 µg/mL; NDGA: 7.02 ± 0.57 µg/mL). The MTT-assay was performed in concentration interval between 8 – 250 µL/mL. All extracts showed high cell viability in lower concentrations (8 – 125 µL/mL). The observed antioxidant-, enzyme-inhibiting and biocompatibility activity of *S.montana* extracts prepared using environmentally friendly and non-toxic solvents makes them promising ingredients for natural cosmetics products with potential anti-inflammatory effects.

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INVESTIGATION OF POLYELECTROLYTE MULTILAYER FILMS BASED ON NATURAL POLYMERS AS POTENTIAL FRUIT COATINGS

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Natural polyelectrolytes, such as polysaccharides, polyamino acids, and proteins, have garnered interest as potential fruit coatings due to their inherent biocompatibility and non-toxicity to humans [1]. Polysaccharides such as chitosan (CS) and carboxymethylcellulose (CMC) possess antibacterial and antifungal properties [2,3], making them useful for a variety of applications in medicine and food packaging industry.

In this study, polyelectrolyte multilayers were prepared using layer-by-layer (LbL) technique on both silica wafers (Si-SiO_2) and apple skin. We investigated the thickness, morphology, and hydrophobicity of the nanofilms using ellipsometry, atomic force microscopy (AFM) and tensiometry techniques. The growth regime has been investigated in different experimental conditions such as pH, salt type and polyelectrolyte concentration. Concentration of the precursor layer (or anchoring layer) was of special interest since it has been found that it affects the adsorption of polyelectrolytes and consequently the growth regime of the multilayer. It was shown that film properties are influenced by the change in all above mentioned conditions.

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IMPURITY CHARACTERIZATION OF SPINGOSINE-1-PHOSPHATE (S1P) MODULATOR ETRASIMOD USING LIQUID CHROMATOGRAPHY-MASS SPECTROMETRY (LC-MS/MS)

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Inflammatory Bowel Disease (IBD), Crohn's disease and ulcerative colitis (UC) are chronic and progressive diseases. Their etiology is not fully understood, and it is thought to involve a combination of genetic and environmental factors leading to an imbalance between pro-inflammatory and anti-inflammatory cytokines in the gastrointestinal tract. Sphingosine-1-phosphate (S1P) receptor modulators represent a new generation of drugs that will make an important turning point in the treatment of IBD [1]. Etrasimod is a second generation S1P receptor modulator intended specifically for the treatment of IBD. Phase II clinical trials in patients with moderate to severe UC in 2019 showed good efficacy of the drug, and it is currently in phase III clinical trials [2]. In this research we developed high-performance liquid chromatography coupled with electrospray ionization triple-quadrupole tandem mass spectrometry (LC-QqQMS/MS) method for quantification of etrasimod and its impurities. The chromatographic analysis of etrasimod was performed on a 10 cm Poroshell 120 column with a gradient mobile phase of ultra-pure water and acetonitrile with the addition of formic acid (0.1 %) as a modifier at a flow rate of 0.8 mL/min in 16 min. Total ion chromatogram (TIC) of product ion showed showed a visible peak of etrasimod with impurities that will be confirmed by forced degradation studies. As a result, this development of analytical methods will be used to test the stability of etrasimod and the compatibility of the drug and excipients.

ACKNOWLEDGMENTS

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MECHANOCHEMICAL SYNTHESIS OF CATALYSTS FOR BIOMASS VALORISATION REACTIONS

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The increasing demand for fuels and chemicals traditionally derived from fossil resources have created the needed to find alternatives based on renewable materials. In this sense, lignocellulosic biomass (hemicellulose, cellulose and lignin) has become in a relevant alternative to obtain materials and added-value products such as furans or γ-valerolactone (GVL) among others [1-3]. In view of aforementioned aim for eco-friendly and sustainable development of processes, the use lignocellulose biomass as a raw material has become a relevant alternative due to is a renewable carbon source, abundant, reachable and non-industry-food competition [4]. In this work, a variety of catalysts have been synthesized employing mechanochemistry technologies (carbon-based materials functionalized with Cu and Fe and Al-SBA-15 materials functionalized with Zr, Ru and Au). This technique provides a high surface area, homogeneous particles deposition, therefore is a fast, efficient and sustainable methodology [5,6]. The catalytic activity of the synthesized materials has been tested in two different biomass valorisation reactions such as vanillin obtention from trans-ferulic acid and the multi-step reaction of furfuryl alcohol (FOL) to obtain γ-Valerolactone (GVL) employing batch, flow and microwave-assisted reactors.

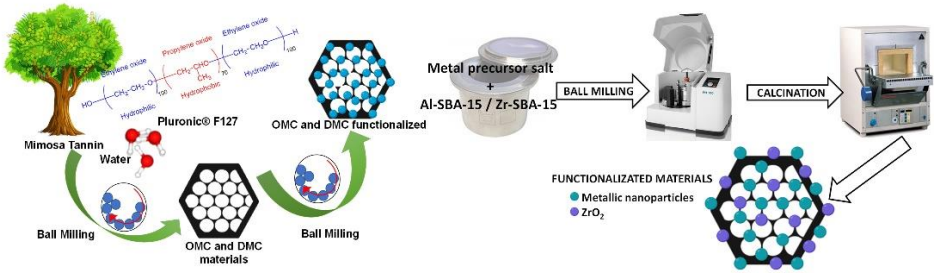

Figure 1. Scheme of materials synthesis procedure.

ACKNOWLEDGMENTS

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CONFORMATIONAL DYNAMICS OF *Bacillus halodurans* MntR TRANSCRIPTION FACTOR – SIGNIFICANCE OF HYDROGEN BOND NETWORK

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The homeostasis of transition metals is crucial for the existence of living organisms and requires complex and well-tuned regulation processes. Both deficiency and excess of particular metal ion can lead to a life-threatening condition [1]. MntR is a metal-sensing transcription factor that belongs to the DtxR/MntR family of proteins selectively responding to transition metals, consequently regulating gene expression. It has been shown that DNA-binding affinity of MntR from *Bacillus subtilis* (*Bs*MntR) is not based on a robust conformer switch caused by metal binding, but rather on a reduction of protein conformational space that favors DNA-binding [2]. MntR from *Bacillus halodurans* (*Bh*MntR) is a structural homologe to *Bs*MntR with 78 % of structural similarity; it is a homodimer with preserved Mn^{2+}-binding site [3]. Molecular dynamics (MD) simulations confirmed structure specificities of Mn^{2+} and apo-protein and led to discovery of crucial hydrogen bonds. Next step was perturbation of one of the most frequent hydrogen bonds: Glu7-Arg76. We introduced mutation *in silico* by computationally mutating Arg76 into Glu76 (mutation R76E). MD simulation showed that Mn^{2+}-R76E-mutant has broader conformational space than wild-type proteins and preferably occupies wider range of conformations. Analyses indicated that most of those conformations are not suitable for DNA binding despite the fact that Mn^{2+} ions are bound in the binding sites. Therefore, Glu7-Arg76 hydrogen bond plays a significant role in stabilization of the most preferred conformer for DNA-binding.

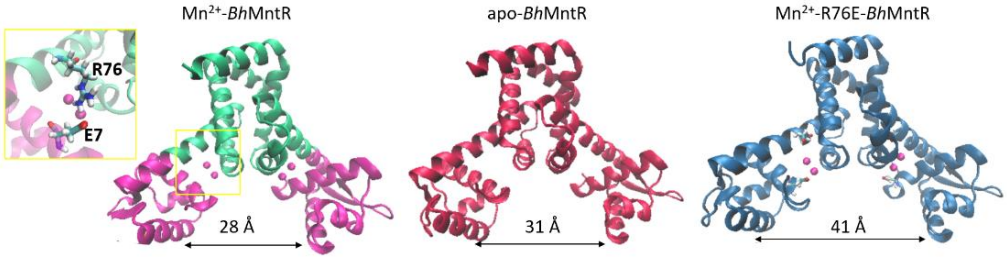

Figure 1. Forms of *Bh*MntR protein investigated via MD simulations.

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DIPEPTIDYL PEPTIDASE III INHIBITION TESTS BY METAL DICATIONS

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It has long been known that the peptidase activity of human dipeptidyl peptidase III (hDPP III) is inhibited by excess of zinc ions [1]. The aim of my research is to determine the effects of different concentrations of metal dication: Zn^{2+}, Mn^{2+}, Co^{2+} and Cu^{2+} on the activity of hDPP III and to identify the inhibitory binding site of the metal. The existence of an inhibitory binding site was hypothesized based on a decrease in hDPP III activity at higher zinc concentrations and the similarity of hDPP III active site with those of carboxypeptidase A and thermolysin in whose crystallographic structures binding of another metal ion was observed in the immediate vicinity of the catalytically active ion [1].

Inhibition of hDPP III by metal dications (Zn^{2+}, Mn^{2+}, Co^{2+} and Cu^{2+}) is being investigated using various experimental and computational methods. For the purposes of experimental research, we prepare holoenzymes by incubating hDPP III with different concentrations of Zn^{2+}, Mn^{2+}, Co^{2+} and Cu^{2+} ions. In the samples thus prepared, metal-protein stoichometry is determined by high-resolution mass spectrometry with inductively coupled plasma (HR-ICP-MS) and microcalorimetric methods (isothermal titration calorimetry, ITC). Using the stopped-flow method, we monitor the decrease in hDPP III enzymatic activity caused by excess metal dications. Finally, using molecular dynamics combined with free binding energy calculus and quantum mechanical - molecular mechanical calculations we identified the zinc binding site and its effect on hDPP III structure and dynamics. Also, following the path of zinc ion exchange, we concluded that, as in the case of anthrax lethal factor [2], it is the so-called associative mode of modification described by relations:

(i) enzyme –metal A + metal B ↔ enzyme –metal A –metal B
(ii) enzyme –metal A –metal B ↔ enzyme –metal B + metal A .

The results of this study allowed us to propose a mechanism by which the inhibitory zinc ion reduces enzyme activity [3].

ACKNOWLEDGMENTS
This work has been fully supported by Croatian Science Foundation under the project IP-2018-01-2936

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MONTE CARLO DOCKING OF QUINUCLIDINE DERIVATIVES AGAINST CHOLINESTERASES

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In a recent study, quinuclidine-based carbamates showed significant anti-acetylcholinesterase and anti-butyrylcholinesterase activity, making them promising central nervous system agents [1]. Binding modes of selected quinuclidine derivatives within cholinesterase's active site were investigated by Monte Carlo quantum chemical docking. The configurational space of each ligand was spanned in 3 translational, 3 rotational, as well as all relevant torsional degrees of freedom and sampled using an implemented stochastic search algorithm [2]. The protein was kept rigid during the docking process while small molecules were allowed to explore the active site. For every generated configuration, single-point calculations were performed using the semiempirical PM7 Hamiltonian. Lowest-energy Michaelis complexes were singled out and optimized at a higher level of theory. Combined QM/QM optimizations were conducted using the ONIOM method and relative standard Gibbs energies of binding were calculated. All quantum chemical calculations were performed using the Gaussian 16 program package [3].

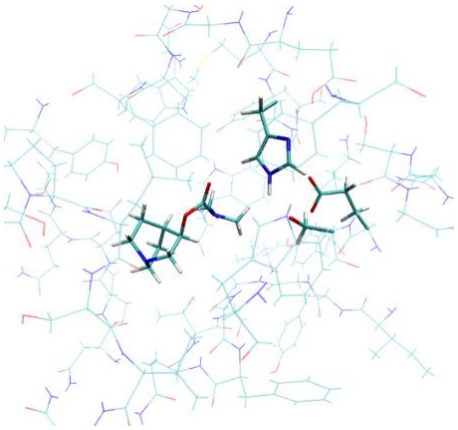

Figure 1. The most significant 3-(*N*,*N*-dimethylcarbamoyloxy)quinuclidine and butyrylcholinesterase Michaelis complex.

ACKNOWLEDGMENTS

This research was funded by the *Croatian Science Foundation*, grants: "*Young researchers' career development - Training New Doctoral Students*" (ESF-DOK-2018-09-3416) and "*Activity and* in silico *guided design of bioactive small molecules*" (IP-2016-06-3775).

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DICYCLOPALLADATED AZOBENZENES – PREPARATION AND CATALYSIS UNDER MECHANOCHEMICAL CONDITIONS

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Palladium-catalyzed cross-coupling reactions of aryl halides with various functionalization reagents are one of the most widely used methods for the preparation of diverse organic compounds, pharmaceuticals, and advanced materials [1,2]. Although cyclopalladated complexes (palladacycles) are widely used as catalysts, the investigations into catalytic properties of doubly palladated compounds are almost non-existent [3]. Recently, solid-state preparative methods have provided faster and environmentally-friendly access to palladacycles compared with time-consuming protocols usually performed in harmful solvents [4]. Furthermore, the mechanochemical protocols for cross-coupling reactions can significantly shorten the reaction times and provide access to a wide array of new products that are sometimes unattainable in solution [5].

In this work, we developed a mechanochemical procedure for the synthesis of new dicyclopalladated azobenzene compounds via ligand-directed C-H bond activation promoted by selected organic acids. *In situ* Raman monitoring of these reactions provided direct insight into the dynamics of the formation of complexes, while NMR and IR spectroscopy were used for the characterization of obtained products. A model Suzuki-Miyaura cross-coupling reaction between 4-bromoazobenzene and phenylboronic acid was carried out under mechanochemical conditions to compare the catalytic potential of prepared palladacycles of azobenzene.

ACKNOWLEDGMENTS

This work has been supported by the Croatian Science Foundation under the project IP-2019-04-9951 (MECHEMFUN).

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SERS EFFICIENCY OF SILVER NANOSPHERES AND NANOSTARS FOR LABEL-FREE DETECTION OF G-QUADRUPLEX

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G-quadruplexes are non-canonical nucleic acid structures of the guanine-rich sequences. They are composed of the stacked planar G-quartets, consisting of four guanine bases connected to each other by Hoogsteen hydrogen bonds [1]. Owing to their unique structural properties and biological functions, G-quadruplexes have attracted significant attention in both basic and applied research, including drug design and development. Among various methods used to understand the structural dynamics and stability of G-quadruplexes, surface-enhanced Raman scattering (SERS) spectroscopy has been recently applied [2]. SERS spectroscopy is a powerful analytical technique which is based on amplification of scattered radiation during adsorption or chemical binding of molecules to a nanostructured metal surface. The enhancement of the Raman scattering is highly dependent on the size, shape, composition, and arrangement of the metal substrate [3]. For instance, sharp tips and edges of the nanostars can generate a stronger electromagnetic field than the smooth surface of the nanospheres [4], making them more sensitive for SERS detection of target molecules.

In this work, two different SERS substrates were used to study structural forms of human telomeric sequence $d[TTAGGG]_4$ (Tel24), capable of forming anti-parallel G-quadruplex in presence of sodium ions. Silver nanospheres and silver nanostars, both stabilized by citrate ions on their surface, were prepared and characterized. SERS spectra of the unfolded Tel24 sequence and Na^+ stabilized G-quadruplex were acquired on silver nanoparticles and the spectral differences, distinctive of the structural forms, analyzed. The efficiency of the used SERS substrates was compared.

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IMPORTANCE OF C-TERMINAL DOMAIN OF *S. coelicolor* SSB PROTEINS FOR COOPERATIVE BINDING TO SINGLE-STRANDED DNA

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Single-stranded DNA-binding (SSB) proteins have a key role in all processes of DNA metabolism. They act as recruitment platform for 20 genome maintenance proteins and while doing so, they modulate their activities. The active homotetramer has multiple binding modes and high affinity for unspecific binding to ssDNA [1]. The SSB_{65} binding mode dominates at higher salts where the protein binds 65 nucleotides in which all four monomeric subunits participate, while in the binding mode SSB_{35} two subunits of the tetramer bind 35 nucleotides at lower salts. Protein SSB from bacteria *Escherichia coli* (EcSSB) forms cooperative nucleoprotein filaments on long ssDNA [2]. Bacteria *Streptomyces coelicolor* has two paralogous genes encoding for the SsbA and SsbB proteins. Our group previously found that SsbA is essential while SsbB participates in chromosomal segregation during sporulation [3]. The C-terminal domain of SsbA protein contains over 50 glycine residues and ends with a conserved DEPPF (acidic) C-terminus which is important for interactions with other proteins. In contrast, the SsbB protein has a much shortened C-terminal domain and lacks an acidic residue at the C-terminus.

In this study analyze how the altered C-terminus of paralogous SSB proteins contribute to their tetramer stability and binding cooperativity. Various mutations in C-terminal region of SsbA and SsbB proteins were generated. Protein stability of wild types and various mutants was analyzed with dynamic light scattering (DLS) and differential scanning calorimetry (DSC). While coopertive binding was mesured with electrophoretic mobility shift assay (EMSA).

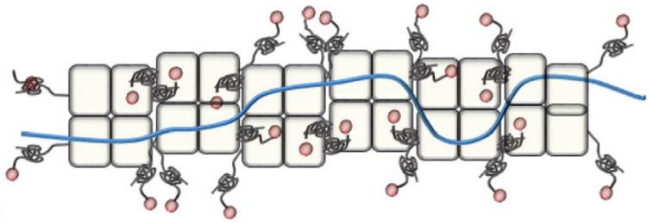

Figure 1. Cooperative binding of EcSSB tetramers on ssDNA in the SSB_{35} mode [2].

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EVOLUTION OF DEEP REINFORCEMENT LEARNING CLASSIFICATION MODELS FOR FRAGRANT COMPOUNDS

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Deep reinforcement learning protocol was utilized in the calculation of best classification models for fragrant compounds on the basis of their ATR spectra and the representation of ATR spectra in the reduced chemical space. The set of fragrant compounds included 6 main types of odor notes of perfumery [1]. A complete set of ATR spectra measured for all compounds was decomposed using the 2nd-order tensor decomposition tool principal component analysis and the data were represented in a reduced space of variable dimension. The position of the particular data point in the reduced space is directly correlated with the chemical composition of aromatic and/or aliphatic functional groups present in the fragrant compound structure.

For each reduced space size, a deep reinforcement learning protocol implemented in the program ***moonee*** [2] was used. Multi-layered neural network (NN) was trained and used for the classification of fragrant compounds. The NN was trained starting with 2 input samples, and then input space was progressively increased in each step for 2 additional samples. Neural networks were trained using the backpropagation algorithm with the criteria of best classification accuracy. During the learning process, several different NN were opposed to each other and the best one was selected for further processing. The evolution of the deep reinforcement learning models depending on the reduced space size will be presented and the best classification model among all investigated dimensionalities will be selected.

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DIFFERENCES IN CIPROFLOXACIN DEGRADATION BETWEEN POWDER AND IMMOBILISED $BiVO_4$ PHOTODEPOSITED PHOTOCATALYSTS

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Ciprofloxacin (CIP) was one of the antibiotics included in the European Commission's Watch list. Among the various strategies, the solar driven photocatalytic process using semiconductors appears to be one of the effective methods to remove antibiotics from aqueous solutions. Removal of used semiconductors is one of the steps in water purification process. When semiconductors are in powder form use of filtration or membrane technologies is required to separate the semiconductor. Those technologies are not perfect, can get clogged up and need maintenance, which makes the water purification process more expensive. That step can be avoided when the materials are immobilised on a appropriate surface before the process. The negative effects of immobilisation are decrease in photocatalytic performance, especially for photodeposited materials, compared to the powder form. In this research, a series of Ag and Fe-modified iso-type homojunction $BiVO_4$ materials (composed of two tetragonal phases)[1,2] were synthesized by simultaneous photodeposition of different amounts of Ag and Fe on the surface of $BiVO_4$. Different time of photodeposition and precursor mass ratio were used as variables. The materials were used as powder and immobilized in three layers on glass plates. All photocatalyst were used for photodegradation of CIP under stimulated sunlight irradiation under pH 8 and concentration of H_2O_2 30 times more then the CIP concentration.

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DEVELOPMENT OF POLYMERIC POUR POINT DEPRESSANTS BASED ON 2-(DIETHYLAMINO)ETHYL METHACRYLATE

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To achieve the desired quality of diesel fuel the use of additives is necessary. They are added in small concentrations to improve the properties of diesel fuel. The main reasons for using additives are: increasing fuel stability during storage, improving flowability at low temperatures, improving fuel combustion, reducing emissions during combustion, ensuring wear protection and increasing fuel economy [1]. In our research, we develop additives for improvement of low-temperature properties. They are mainly binary or ternary copolymers such as ethylene vinyl acetate, methacrylate-based polymers, alpha-olefin copolymers and others. Their structure usually consists of a non-polar part (often a side chain) and a polar part (one or more polar groups). When the side chain is similar in length as paraffins in diesel, it provides nucleation sites and/or co-crystallization sites for the formation of paraffin crystals. The polar part has a strong influence on the growth of paraffin crystals by limiting their size and affecting their shape [2]. In this study, we synthesized polymeric methacrylate additives with functional 2-(diethylamino)ethyl methacrylate comonomers in their structure and investigated the influence of different amounts of the functional comonomer on the low-temperature properties of diesel fuel. The synthesized additives changed the crystallization behavior of diesel observed by differential scanning calorimetry (DSC) and optical microscopy with polarization. The standard ASTM D5950 pour point (PP) test showed a large improvement of more than 20 °C compared to non-additivated diesel.

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SYNTHESIS AND CHARACTERIZATION OF THE RARE-EARTH ZIRCONATE PYROCHLORE $RE_2Zr_2O_7$ AND THE κ-$RE_2Zr_2O_8$ PHASES (RE=La, Y, Gd, Pr, Ce and Zr)

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Tetragonal solid solutions *t*-$Ce_{0.5}Zr_{0.5}O_2$ and *t*-$La_{0.1}Y_{0.1}Gd_{0.1}Pr_{0.1}Ce_{0.1}Zr_{0.5}O_2$ were synthesized using a low-cost and environmentally friendly citrate sol-gel route followed by calcination at 600 °C (Figure 1.). Solid solutions were reduced by calcination at 1500 °C in a gaseous mixture of 3% hydrogen in argon, to form pyrochlore phases $Ce_2Zr_2O_7$ and $(La_{0.2}Y_{0.2}Gd_{0.2}Pr_{0.2}Ce_{0.2})_2Zr_2O_7$. The last step of phase transformations is the re-oxidation of pyrochlore phases at 600 °C to kappa phases *κ*-$Ce_2Zr_2O_8$ and *κ*-$(La_{0.2}Y_{0.2}Gd_{0.2}Pr_{0.2}Ce_{0.2})_2Zr_2O_8$, respectively [1]. All synthesized materials were characterized by the Rietveld refinement of X-ray powder diffraction patterns. Raman spectroscopy was used to complement XRD analysis and to calculate the Ce^{3+}/Ce^{4+} ratio. Scanning electron microscopy coupled with Energy-dispersive X-ray spectroscopy (SEM-EDS) was a useful method to inspect the morphology and chemical content of each compound. Oxygen uptake of pyrochlore forms was monitored by thermogravimetric analysis (TGA). Structural differences between tetragonal, pyrochlore and kappa forms of synthesized compounds were observed. The reversible exchange of Ce^{4+} to Ce^{3+} and vice versa makes ceria-based materials suitable as catalysts in oxidation reactions [2].

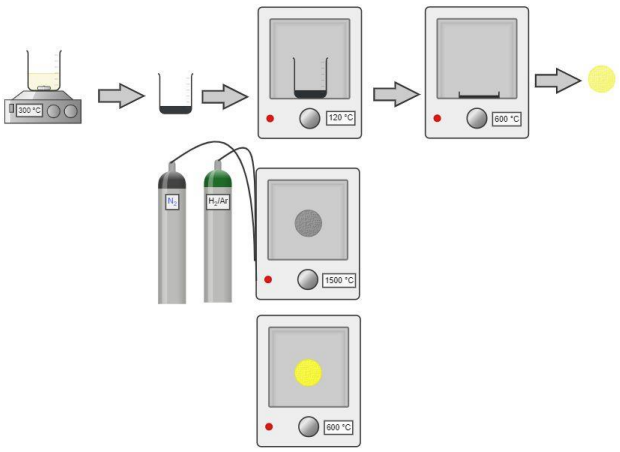

Figure 1. Schematic representation of the step-by-step synthesis of the rare-earth zirconates.

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SPRi STUDY OF *N*-ACETYL GLUCOSAMINE SPECIFIC LECTIN INTERACTIONS WITH PEPTIDOGLYCAN MONOMER FUNCTIONALIZED GOLD BIOCHIPS

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Peptidoglycan monomer (PGM) is a disaccharide pentapeptide isolated from *B. divaricatum* that shows immunostimulatory, immunomodulatory, antitumor, and antimetastatic activity [1]. PGM, a fragment of bacterial peptidoglycan, is recognized by the innate immune system through pattern recognition receptors (PRR). Lectins are naturally occurring carbohydrate-binding proteins and some of them mediate pathogen recognition by binding glycan epitopes on pathogens. Carbohydrate-lectin interactions are extensively studied because of the lectin's potential usage for PRR targeting in the fields of infectious diseases and cancer research [2]. In this study, we were primarily interested in investigating the interaction of peptidoglycan monomer and lectins that specifically recognize the *N*-acetyl glucosamine moiety (e.g. WGA, UEA-II, GS-II) by surface plasmon resonance imaging (SPRi). SPR-based methods are a powerful tool for the investigation of interactions between biomolecules in real-time, enabling quick, label-free characterization of a variety of molecular interactions. Gold biochips were successfully functionalized with PGM and its metal complexes with Cu^{2+} and Zn^{2+} ions, in three steps shown in Figure 1. The results show that PGM was effectively recognized by WGA and that interactions are enhanced when PGM's metal complexes with Cu and Zn were employed.

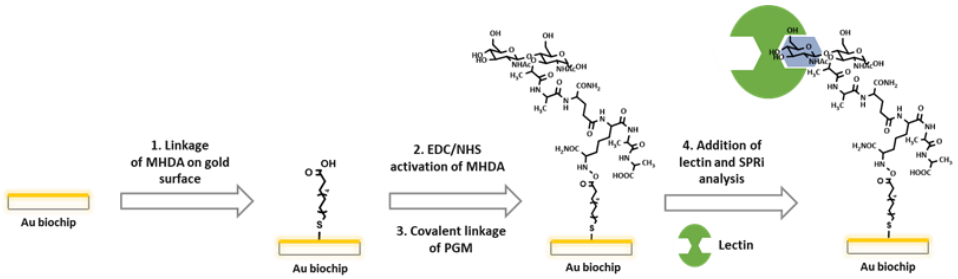

Figure 1. Schematic representation of PGM functionalization of gold-coated biochip and SPRi analysis of the interaction of peptidoglycan monomer and lectins.

ACKNOWLEDGMENTS

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SYNTHESIS AND GAS SENSING PROPERTIES OF PLATINUM NANOPARTICLES SUPPORTED ON IRON OXIDES

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The α-Fe_2O_3 (hematite) powder samples were synthesized mechanochemically in spherical morphology and hydrothermally in nanotube and nanoring morphologies. Stoichiometric Fe_3O_4 (magnetite) was synthesized by annealing α-Fe_2O_3 samples in a furnace at 360°C under continuous hydrogen gas flow. The synthesized Fe_3O_4 powders preserved the original morphology of α-Fe_2O_3 nanotubes and nanorings. Platinum was dispersed on the surface of the α-Fe_2O_3 and Fe_3O_4 powders with platinum(II) acetylacetonate dissolved in toluene. Atomic resolution scanning transmission electron microscopy (AR STEM) showed that the platinum was homogeneously dispersed on the α-Fe_2O_3 in the form of small platinum nanoparticles (Fig. 1a). The gas sensor properties of the samples were measured by depositing Pt/α-Fe_2O_3 suspensions on glass substrates with interdigitated gold electrodes using the drop casting technique. The changes in electrical resistance of the samples upon exposure to H_2 gas were measured at 433 K, 483 K and 533 K. Fig. 1b shows the response of the synthesized Pt/α-Fe_2O_3 (FePt5 with 5 mol% Pt and FePt10 with 10 mol% Pt) gas sensor as the relative change in electrical resistance, $\Delta R/R_0$, as a function of H_2 concentration. The sensitivity of the samples to hydrogen gas was optimized as a function of platinum dispersion and loading as well as sample morphology (sphere, nanotubes, nanorings) and phase composition (α-Fe_2O_3 versus Fe_3O_4) [1].

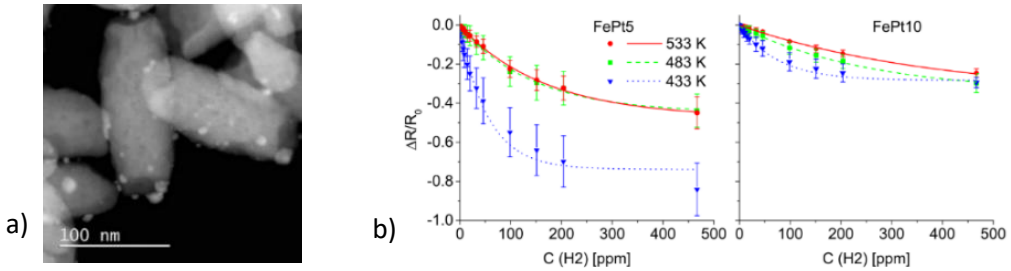

Fig. 1: (a) AR STEM image of small platinum nanoparticles (brighter small dots) dispersed on α-Fe_2O_3, (b) response vs. H_2 concentration of FePt5 (left), and FePt10 (right) at different temperatures. Lines show the best fit exponential.

ACKNOWLEDGMENTS

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PHOTOCATALYTIC CO_2 HYDROGENATION USING CERIA-BASED HIGH ENTROPY OXIDE PHOTOCATALYSTS

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Photocatalytic CO_2 conversion is a promising clean technology for reducing greenhouse gases in the atmosphere [1]. A semiconductor photocatalyst absorbs light and converts CO_2 via various pathways, resulting in different products [2, 3]. However, for photocatalytic CO_2 conversion to be possible, the photocatalyst must possess specific qualities, such as appropriate bandgap, band structure etc. Even though there are many photocatalysts available nowadays, it is crucial to continue searching for new and highly active photocatalyst materials to achieve practical applications. The study of high entropy oxides (HEOs) has emerged as a rapidly growing and dynamic field within material science. These materials, consisting of a mixture of various elements in single-phase compounds, are known for their unique properties and crystal structures due to their high configurational entropy [4]. In this research, six ceria-based high entropy oxides were prepared using environmentally friendly sol-gel citrate route. To better understand the photocatalytic behavior, thorough structural analysis and surface studies were conducted. The catalytic performance of the oxides was performed in a model heterogeneous reaction (Photocatalytic CO_2 hydrogenation), by which we proved their possible application as highly efficient photocatalysts for CO_2 conversion.

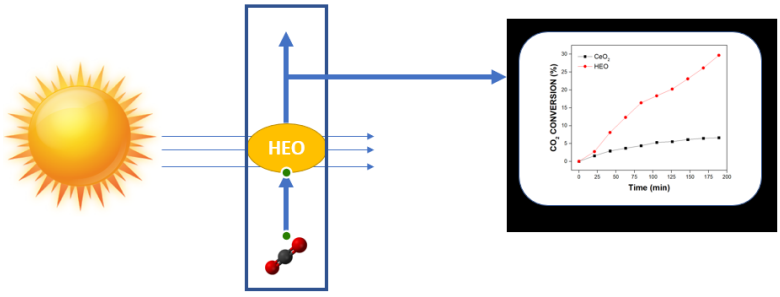

Figure 1. Schematic overview of the research.

ACKNOWLEDGMENTS

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TUNNELING SPLITTINGS IN VIBRATIONALLY EXCITED STATES OF THE WATER HEXAMER PRISM

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The water hexamer is an assembly of six water molecules that are weakly-bound by hydrogen bonds (Fig. 1.). This particular cluster is probably the most intriguing one out of a plethora of other studied water clusters because it is the smallest one with 3D structure. At very low temperatures, molecules in the cluster can rearrange and generate new, equivalent structures. These structures are connected to one another by some symmetry operation. It is observed that the water hexamer system has a great number of possible minima, but only the ones connected by short and energetically accessible tunneling paths cause significantly observable splittings, which exhibit a characteristic doublet-of-triplets pattern in the spectrum [1]. The explanation of the specific splitting pattern is found to involve the two main tunneling pathways: antigeared and geared (Fig. 1.) [2].

The method used for calculating the tunneling splittings is based on instanton theory. In order to obtain the ground-state splitting, the procedure involves constructing a WKB wavefunction along the instanton path and its harmonic surroundings for each well and putting the acquired wavefunction in the well-known Herring formula which ultimately results in tunneling splitting. The excited state splittings are generated using an analogue approach [3].

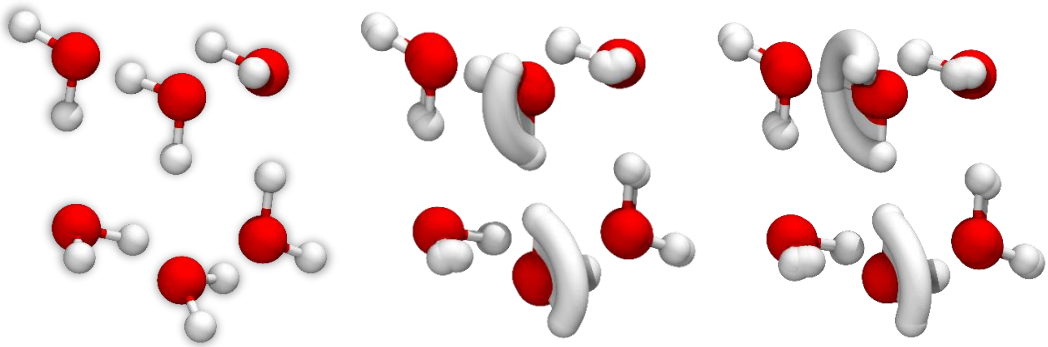

Figure 1. Water hexamer prism structure (left), two main tunneling pathways: antigeared (middle) and geared (right).

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DETECTION OF MICROPLASTICS IN WATER BY MICRO-RAMAN SPECTROSCOPY

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Microplastics (MPs) are defined as small plastic particles, typical range is between 1 µm and 5 mm in size [1]. MP enter the environment either through the degradation of macroplastics or as primary microplastics, i.e. particles intentionally produced in micro size. The lack of standardised methods for detecting MP in drinking water makes reproducibility difficult [2]. The aim of our study is therefore to develop and optimise a method for identification and quantification of MPs by micro-Raman spectroscopy. Drinking water is analysed for microplastic contamination by filtering the water on silicon filters which are then analysed to within 1 µm using micro-Raman spectroscopy. Since Raman measurement of entire filter surface is tedious and can even take more than 24 hours for a single filter, we used a subsampling model based on which only part of filter is analysed and the results are extrapolated to whole filter surface. Previous studies have shown that even ultrapure water contains microplastic particles, which is why MP in ultrapure water must be subtracted from the total MP content in the sample water. Initial results showed that MP is present in drinking water and ultrapure water and the most common polymer types are PET and PE.

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CONTINUOUS-WAVE EPR STUDY OF MOF-525 AND PCN-223 DOPED WITH VARIOUS PARAMAGNETIC CENTERS

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Metal-organic frameworks (MOFs) are porous coordination polymers built from metal nodes and organic linkers [1]. These materials have a potential to be used in spintronics as molecular spin qubits [2]. The magnetic properties of two multivariate porphyrinic Zr-MOFs: MOF-525 and PCN-223 [2], with 10% copper(II) or vanadyl(IV) cations in porphyrin linker, were examined by continuous-wave electron paramagnetic resonance (CW-EPR) spectroscopy. The simulations of the experimental data, obtained using EasySpin software [3] show that the CW-EPR spectra of MOF-525 and PCN-223 with copper(II) cations exhibit superhyperfine interaction with four neighboring nitrogen nuclear spins (I_N = 1). In contrast, such interactions are not visible for MOF-525 and PCN-223 with vanadyl(IV) cations. This can be explained by the fact that the unpaired electron in the vanadyl(IV) cation resides in the d_{xy} orbital which is well separated from the orbitals of the nitrogen atoms [4,5].

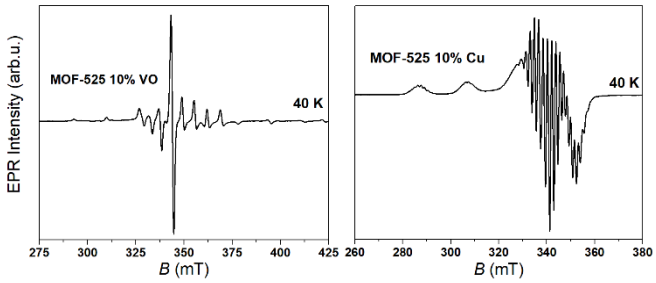

Figure 1. CW-EPR spectra of MOF-525 with 10% vanadyl(IV) or copper(II) cations recorded at 40 K.

ACKNOWLEDGMENTS

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BIORELEVANT DISSOLUTION OF BIOLOGICALLY ACTIVE COMPONENTS FROM HERBAL TABLETS USED IN THE TREATMENT OF INFLAMMATORY BOWEL DISEASES

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Inflammatory bowel disease (IBD) is a continuously increasing worldwide disease and affects people of all ages. More than half of these patients use herbal dietary supplements to alleviate the symptoms of IBD [1]. Curcuminoid compounds present in turmeric, boswellic acids as pentacyclic terpenoid molecules from frankincense resin, andrographolides as diterpene lactones isolated from green chiretta, and piperine as a piperidine alkaloid from black pepper fruits are the most abundant biologically active substances in herbal dietary supplements for the treatment of IBD.
Since today the use of dietary supplements is widespread and constantly increasing, this study aimed to analyze the dissolution of those mentioned biologically active components from oral herbal preparations in biorelevant media.
Samples in tablet dosage form were collected from local pharmacies and purchased from the Internet. All dietary supplements were classified as botanical monopreparations and multipreparations.
In vitro dissolution studies were conducted using a USP dissolution (paddle) apparatus 2 (Erweka DT600, Erweka GmbH, Langen, Germany). The herbal tablets were dispersed in 900 mL of USP-recommended dissolution medium (1 % sodium lauryl sulfate), fasted/fed simulated gastric and small intestinal fluids (FaSSGF, FaSSIF/FeSSIF) at 37 °C [2]. During dissolution, 1 mL of sample was collected at each time point up to 120 min and filtered through Minisart RC4, 0.45 µ m filters (Sartorius, Germany), which did not retain any of the analytes. All samples were analyzed in duplicate. The concentration of biologically active components in the filtrate was analyzed using an HPLC-DAD assay. Chromatographic analyses were performed on a Shimadzu Nexera chromatographic system.
Based on the obtained results (similarity factor, f_2 value < 50 %), the *in vitro* release profile of the biologically active substance from herbal tablets depends on the composition of the biorelevant medium.

ACKNOWLEDGMENTS

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SPATIAL VISUALIZATION OF THE ENVIRONMENTAL IMPACT OF SEDIMENT-HOSTED Cu DEPOSITS IN ALTA-KVÆNANGEN TECTONIC WINDOW, NORTHERN NORWAY

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The Paleoproterozoic Alta-Kvænangen Tectonic Window (AKTW) in northern Norway contains numerous sediment-hosted Cu deposits. The mineralisation occurs in form of quartz-carbonate veins that crosscut the Storviknes sedimentary sequence and the underlying Kvenvik volcano-sedimentary complex. The ore paragenesis consists of chalcopyrite, bornite, and digenite, associated with minor amounts of galena, covellite, molybdenite, and wulfenite. The study area was subjected to an extensive mining activity in the late 19th century, resulting with several abandoned tailing sites [1]. The area is covered with a thick snow cover almost all year round, with the snow melting period in June and July. The main objective of this study is to visualise the extend and environmental impacts of the sediment-hosted Cu deposits in the Arctic climatic conditions. In total, 44 stream sediment samples were collected along 150 – 250 m intervals of three streams (Annaselva, Møllneselva and Brakkelva) that drain the Cu mineralization in both Storviknes and Kvenvik formations. The analyses were carried out on the < 63 µm fraction and included bulk lithogeochemical analysis, mineral characterization by X-Ray powder diffraction (XRD), and 7-step sequential extraction adjusted for Cu mining waste with analysis of 27 elements in extracts. The obtained concentrations both in bulk samples and bound on different phases were analysed to detect spatial trends and potential correlation with mineral phases detected by XRD. The spatial analysis included analysing morphological features using digital elevation model (DEM), analysis of hydrological features by determining watersheds for each sampling point, adding measured concentrations of metals of interest to each watershed, and overlaying all created maps. The bulk lithogeochemistry data shows a general enrichment in Ag, Bi, Ca, Cu and in the Brakkelva watershed, in Ag, Ca, Te, Sb, and Cu in the Møllneselva watershed, and in Hg, Sb, and Mn in the Annaselva watershed. The sum of first two steps of sequential extraction analysis represents phases that are easily dissolved. These concentrations were visualized as well, however, due to much smaller number of samples trends cannot be explicitly determined. Many mentioned metals show higher concentrations at sampling points downstream then at sampling points upstream. These higher concentrations downstream, show that dilution is suppressed by many areas where mineralisation is exposed to weathering, which increase the concentrations of different metals in stream sediments, leading to potential overloading downstream.

ACKNOWLEDGMENTS

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FACIES CHANGES AS A REFLECTION OF TECTONIC ACTIVITY IN THE DINARIC FORELAND BASIN (NORTHERN DALMATIA, CROATIA)

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The Paleogene period in the area of northern Dalmatia was marked by significant tectonic activity, triggered by the collision of the Adriatic microplate with the Euroasian plate margin. The collision caused the uplift of the Dinarides mountain range, in front of which the Dinaric Foreland Basin was formed simultaneously. Progressive collision and thrusting during the middle Eocene to the Oligocene converted the inner foreland basin into a ''piggyback'' basin [1], or orogeny wedge-top basin [2]. A series of blind-thrust growth folds separated the wedge-top basin into steep asymmetrical, partially connected sub-basins. The above-mentioned tectonic activities left their mark in the sedimentary record. Data for this study have been collected by detailed sedimentological logging of outcrops in the area of Karin Gornji in the canyon of the Bijela River, in the northeastern part of the Novigrad sub-basin, and interpreted using facies analysis. The study succession is about 240 m thick and comprises carbonate conglomerates, calcarenites, calcisiltites and calcilutites with different sedimentary structures and fossil content. Spatially and genetically related facies are grouped into facies associations which represent specific depositional environments – in this particular case, shoal-water deltas and braided rivers. The lower part of the succession shows several transgressive-regressive delta cycles separated by flooding surfaces, while the uppermost part of the succession comprises only fluvial deposits. Such distribution of facies associations suggests that the northeastern margin of the Novigrad sub-basin was tectonically active during deposition of shoal-water deltas. During the late Palaeogene the Novigrad sub-basin was filled with fluvial sediments, a balance between sedimentation and subsidence was reached, along with a steady-state within the foreland basin [3]. These preliminary results will enable a better understanding of events in the past and the reconstruction of the entire depositional area.

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IMPACT OF MEASUREMENT UNCERTAINTY ON RISK ASSESSMENT

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The product conformity assessment process refers to the assessment of the risk of accepting a non-conforming product as conforming or rejecting a conforming product as non-conforming. If the item (measurement result) is accepted as satisfactory but does not conform to specification, it is the consumer's risk. If the item is rejected but actually conforms to specification, we are talking about the producer's risk. The risk assessment is based on a Bayesian model that combines the prior knowledge about data provided by the specifications and the measurements results. The application of the conformity assessment procedure is provided on the example of the thickness of the epoxy coating on water pipes made of gray cast iron [1]. The thickness of the coating on the outer smooth part of the pipe was measuring. According to the EN 877 standard, the thickness of the epoxy coating for pipes must be at least 70 µm in order to comply with designed corrosivity. The acceptance interval for the optimally estimated coating thickness is determined according to the metrology standards given by The International Bureau of Weights and Measures (BIPM) [2]. The prior data provided by producer's specifications are modeled via gamma distribution. The results of coating thickness measurements belong to a normal distribution and are modeled via a likelihood function. The product of the gamma distribution and the likelihood function is a subintegral function in the risk assessment equation. This integral has no closed solution form and must be solved numerically. One of the variables on which the solution of this integral depends is the measurement uncertainty. The impact of measurement uncertainty on consumer and producer risk assessment was carried out for four different values of measurement uncertainty. The results showed that the greater measurement uncertainty results with a higher global producer's and consumer's risk.

ACKNOWLEDGMENTS

The data used in the work were collected within the framework of the project: “Development of anticorrosion protection system for multipurpose pipe use”, grant number KK.01.1.1.07.0045. This work was supported by the European Regional Development Fund under the Operational Program Competitiveness and Cohesion 2014–2020. We thank the project participants for the provided data.

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COMPOSITION OF EPIBIOTA IN THE CANOPIES OF MARINE FORESTS OF WESTERN ISTRIAN COAST

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In the recent past, Istrian coastal waters were known to host rich fucalean assemblages [1-2]. However, this has changed following a massive regression of *Cystoseira sensu lato* and *Sargassum sp.* marine forests, that has been documented with its peaks and ebbs since the late 1960's [3–5]. C*ystoseira*, *Ericaria* and *Gongolaria* species can host complex communities in their canopies and can potentially provide a plethora of ecosystem services such as feeding grounds, shelter, rearing areas and refugia from predation [6–8]. To assess the possible patterns and differences in the epibiont community structure, the fucalean algae were sampled for their epiphytes whose composition was analyzed according to host species and localities of collection. Data were collected during macroalgal surveys at 7 different localities in the western and south-western part of the Istrian Coast in early summer 2021 and 2022. The results shows the variation of epibiont composition in multiple categories, across the host species and sampling locations, covering all the remaining large settlements of canopy forming fucalean species on the western and southern Istrian coast that can still be sampled without endangering the settlements. While no significant differences between localities were detected, there was a significant difference when comparing epiphyte composition across host species. The variations in epibiont composition may be associated with fucalean assemblage composition, local trophic conditions or local exposure to winds or waves. Such results of studying epibiont diversity and composition can serve as an indicator for the detection of incoming community succession or changes due to local abiotic, biotic, or anthropogenic factors if properly analyzed and interpreted [8].

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FIRST RECORD OF THE DINOFLAGELLATE *Tripos rotundatus* IN THE ADRIATIC SEA

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Dinoflagellates are an important group of protists in marine and freshwaters with a remarkable diversity of life forms (free-living, parasites and mutualistic symbionts), habitats (plankton and benthos) and nutrition modes (heterotrophic, chloroplast-containing) [1]. About ~6000 taxa (species and infraspecific units) of dinoflagellates are currently accepted [2]. In the Mediterranean Sea, 673 taxa have been identified, while in the Adriatic 322 taxa have been reported [3]. The genus *Tripos* Bory is globally widespread in marine waters and is the most diverse genus among dinoflagellates with ~800 taxa described. These species are typically large and robust, often with horns [4]. Members of this genus were previously included in the genus *Ceratium* Schrank until morphological and molecular data supported restricting *Ceratium* to freshwater species [5]. According to my best knowledge, the taxa *Tripos rotundatus* (Jørgensen) F.Gómez represents the first record for the Adriatic and the Mediterranean Sea [6]. The taxa were found in a plankton net sample originating from the coastal station in the southern Adriatic, in the summer of 2021. A morphologically very similar species is *Tripos digitatus* (Schütt) Gómez [6], which was found in the Mediterranean [7,8] and in the northern Adriatic as well [9]. The morphological characteristic between these two taxa has been recently explained [5]. Their epitheca and hypotheca are distinct, with the epitheca of *T. digitatus* is strongly reflected towards the dorsal side, the left antapical horn is anteriorly directed and the apex showed a short projection. In *T. rotundatus* epitheca is less bent towards the dorsal side, the short projection on the apex is missing, and the left antapical horn is directed laterally. This finding contributes to a better understanding of the diversity of dinoflagellates in the Adriatic Sea.

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MARINE PLASTIC LITTER, TRACE METALS AND BACTERIA: SEASONAL AND SPATIAL DISTRIBUTION ON TWO ADRIATIC ISLANDS

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Despite awareness of the harmful effects of plastics on the environment and human health, global plastic production continues to rise, leading to increased ocean contamination and harm to marine life. Marine plastic litter (MPL) can serve as transport vector for marine pollutants, including trace metals (TM) with potential toxicity and pathogenic bacteria [1]. The Adriatic Sea is a valuable subject for research due to its semi-enclosed nature and high levels of plastic litter pollution caused by winds and ocean currents. MPL and sediment samples were collected for analysis before and after the summer season at three locations including Sakarun beach on the Dugi Otok Island and two beaches, Uska and Zace on the Lastovo Island. Polymer types were identified by Fourier transform infrared spectroscopy. The levels of TM (Zn, Cd, Pb, Cu, Ni, Co) and bacteria were examined both on MPL and in sediment. Voltammetry was used to analyze the TM amounts, while a microbial assay was performed using Marine and TCBS agar. The bacteria were identified using MALDI TOF MS. All analyzed sediment are bioclastic carbonate sands, particularly on the Sakarun beach. The dominance of polypropylene polymer was observed across all locations. Cadmium was the only metal among those analyzed on MPL that displayed varying concentrations with season and location. Bacterial communities on the MPL surface differed according to season and location, with *Bacillus spp.* represented in the postseason. The preseason sediment samples were characterized by *Vibrio alginolyticus, V. pomeroy* and *V. gigantis*, and posteason with *Bacillus spp*., *V. harveyi* and *V. chagasii*. Sediments from Sakarun beach contained *Bacillus spp*., *V. harveyi* and *V. gigantis*, while Lastovo coves were determined by *V. pomeroy* and *V. harveyi*.

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CONDITION INDEX OF THE MEDITERRANEAN SCALLOP *Pecten jacobaeus* (Linnaeus, 1758) FROM THE KRKA RIVER ESTUARY

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The Mediterranean scallop *Pecten jacobaeus* (Linnaeus, 1758) is the largest bivalve mollusc from the Pectinidae family that lives in the Mediterranean Sea. This commercially exploited species is in high demand, mainly because of its large adductor muscle, which is the most sought after part of its meat. It is exploited mainly through fishing [1], but its market value makes it an interesting species for the introduction into the aquaculture. In this research, we investigated condition index (CI) of *Pecten jacobaeus* from the Krka River estuary. The CI measurement is generally expressed as the proportion of meat to total shell weight and can vary depending on the size of the individual, reproductive cycle, season, and local environmental conditions, such as sea temperature and food availability [1, 2]. In the period from December 2021 to December 2022, approximately 20 specimens were collected monthly from the same area in the Krka River estuary. The parameters measured include shell dimensions (length, height and width in mm), total mass of the shell (g) and the mass of soft tissue (g), wet and dry weight, after processing in the dryer at 60 °C for 48 h. The condition index was calculated according to the Lucas and Beninger [3] method: CI= (soft tissue dry weight (g)/shell dry weight (g)) x 100.

Our results indicate that the CI of *P. jacobaeus* from the Krka River estuary is highest in late winter/early spring, followed by a rapid decline by the end of spring. This is consistent with previous research done by Marguš and Teskeredžić (2005) who studied the reproductive cycle of *P. jacobaeus* in the Krka River estuary and found that the gonadosomatic index (GSI), which is used to assess the reproductive status of bivalves [2], was highest in late winter/early spring, followed by a rapid decline after spawning. High IC values were again recorded in the period from July to October, probably due to the result of storage of reserves during the period of food abundance in the main storage organs: adductor muscle and digestive gland [1]. This period followed another decline in IC levels, with the lowest values recorded in the winter months, suggesting that these reserves are used to maintain supply during periods of food shortage.

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PHENOTYPIC CHARACTERISTICS OF FOUR-SPOTTED MEGRIM *Lepidorhombus boscii* (Risso, 1810) IN THE EASTERN ADRIATIC SEA

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The four-spotted megrim *Lepidorhombus boscii* (Risso, 1810) is a demersal flatfish distributed on soft bottoms in the northeast Atlantic Ocean, and Mediterranean and Black Sea at depths between 60 and 500 m, mostly from 200 to 300 m [1]. It feeds mainly on pelagic fish, cephalopods, and crustaceans [2, 3]. In this study, a total of 270 specimens of the four-spotted megrim *L. boscii* were biometrically analyzed. A total of 18 morphometric and 6 meristic features were measured. Samples were collected monthly, from July 2020 to June 2021, in the central eastern Adriatic Sea, by bottom-trawl net. The sample consisted of 145 females (53.7%) and 125 males (46.3%). Sex was determined macroscopically according to the shape and appearance of gonads. The total body lengths of analyzed individuals ranged from 12.5 to 34.0 cm (mean ± st.dev. = 20.96 ± 3.54 cm). Wider ranges of analyzed values were found in males for 11 morphometric measures, while for 7 morphometric features the range was wider in females. The differences in the mean values of the analyzed morphometric measurements between males and females showed a statistical significance (*t-test,* $P < 0.05$) only in the ratio of pectoral fin length to standard body length (*Lp/Ls*). The differences in the mean values of the analyzed meristic features between males and females were observed only in the number of vertebrae (*t-test*, $P < 0.05$). The data represent the first complete biometric description of *L. boscii* in the Adriatic Sea.

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IMPACT OF LAND USE/LAND COVER CHANGES ON THE URBAN HEAT LOAD - A CASE STUDY FOR THE CITY OF DUBROVNIK

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In this study, land use/land cover changes were examined to investigate their impact on the urban heat load of the City of Dubrovnik in the present and future climate. Dubrovnik is situated in the Mediterranean which has been referenced as one of the most responsive regions to climate change. Therefore, it is crucial to investigate the effects of different substrates on the heat load and its possible mitigation. Firstly, urban heat load, in the current morphology of the city, is investigated in the present and future climate conditions by using data observed at the local meteorological station and data obtained from regional climate models of the EURO-CORDEX initiative. Also, the urban climate model MUKLIMO_3 is utilized to obtain the spatial distribution of the heat load. Climate indices based on measured data (summer days and tropical nights) show that the heat load has been increasing in the last 50 years. The spatial distribution of the heat load in the City of Dubrovnik in the present climate indicates that the highest heat load is in the public and residential parts of the city. Furthermore, during the nighttime, heat load decreases with a reduction in the density of buildings. Climate indices obtained by simulations of the model MUKLIMO_3 for future climate scenarios (rcp4.5 and rcp8.5) show that the heat load will increase in the entire city domain, with the strongest increase in its urbanized parts. In this study, the impact of modifications in land use/land cover (like changes in the fraction of buildings, impervious surfaces, vegetation and albedo of the roofs) on the heat load are examined [1, 2]. It is demonstrated that these changes will decrease the heat load to some extent. However, the impact is locally limited and significantly smaller than the contribution of global warming [3]. Therefore, land use/land cover changes can mitigate the urban heat load. However, even more comprehensive interventions cannot eliminate the overall increase in the urban heat load due to global warming.

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APPLICATION OF ION IRRADIATION IN FUSION MATERIALS RESEARCH

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The development of future fusion power plants requires among other things research into the properties of materials under fusion spectrum neutron irradiation [1]. However, with the current lack of neutron sources of sufficient flux to create these conditions, heavy ion irradiation is one of the alternatives currently used to emulate the neutron damage environment [2]. Such experiments are conducted at the Laboratory for ion beam interactions of the Ruđer Bošković institute [3].

Since the fundamental physical interaction is different for ions as opposed to neutrons, research is also carried out into these effects to validate this experimental method. Here we demonstrate some basic findings regarding the methodology of ion irradiation. In particular, it is shown that the sample microstructure can be significantly altered with dose rate variation.

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A CORRELATION STUDY OF THE PROTON DECAY SIGNATURES INDUCED THROUGH THE GAUGE BOSON AND SCALAR LEPTOQUARK MEDIATIONS

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The SU(5) unification of interactions and fields has been one of the most appealing ideas in elementary particle physics for the last five decades. Since there are various mechanisms to generate experimentally viable neutrino masses within the SU(5) context, there are also numerous models that address this important question. Another equally relevant issue is whether one can address masses of charged fermions within the SU(5) framework in a simple, yet realistic manner. Even though there are a plethora of SU(5) models in the literature that allow viable masses of neutral and charged fermions, it was only recently [1,2] that a possibility to provide direct connection between these two issues within the SU(5) framework has finally emerged. We concentrate on such a model that, due to its simplicity, also provides connection between proton decay signatures [3,4,5] induced by the gauge boson and scalar leptoquark mediations to investigate its testability if and when proton decay is discovered.

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PLASMAPAUSE EVOLUTION BASED ON THEMIS DATA: 3 CASES FROM FEBRUARY TO MAY 2010

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Plasmasphere is a region in the inner magnetosphere consisting of cold dense plasma [1]. Its outer boundary, the plasmapause, is characterized by a sharp decrease in density over a short distance [2]. Plasmapause location depends on geomagnetic conditions, and it is important because it separates completely different plasma environments. However, the mechanism of plasmapause formation is still unclear. There are two theories, last closed streamline and interchange instability, with different results: the former concludes that, due to changes in geomagnetic conditions, plasmapause forms simultaneously at all magnetic local times (MLTs), while the latter proposes that plasmapause forms close to midnight (MLT=0), then propagates to later MLTs [3].

Here, an analysis of three cases, spanning from February to May 2010 is presented. Each case covers a few days containing an increase in geomagnetic activity indicated by the Kp index. Analysis is based on electron density data calculated from measurements by THEMIS satellites A, D, and E. First, electron density profiles are derived, showing density data between satellite's perigee and apogee. These profiles are then separated into two groups that cover different MLTs, depending on whether they are obtained during the inbound or outbound part of the satellite's trajectory. Temporal changes in density are compared between the two groups, as well as to the changes in Kp index, and are interpreted in favor of interchange instability mechanism for plasmapause formation. This is in agreement with results from observations by THEMIS [4][5], CRESS [6], and Cluster [7] satellites, and a model based on interchange instability [8].

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INVESTIGATION OF ELECTRICAL AND MAGNETIC PROPERTIES OF VARIOUS INTERCALATED SYSTEMS

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Transition metal dichalcogenides (TMDs) are layered materials that, due to their reduced dimensionality, host interesting phases such as charge density waves (CDW) and superconductivity. Intercalation by 1st row transition metals offers the possibility of fine-tuning magnetic and electronic properties [1]. We synthesized high-quality single crystals of Ni_xNbS_2 in a wide intercalation range of $0.01<x<0.6$, and stoichiometric $Co_{1/3}TaS_2$ which turned out to be more challenging. In Ni_xNbS_2 we track the suppression of superconductivity and the development of the antiferromagnetic (AF) phase. We also investigate the effect of disorder on the magnetic ground state. It's interesting to notice that although both compounds order antiferromagnetically, a ferromagnetic component also exists indicating the presence of Dzyaloshinskii-Moriya interaction. As a cleaner way to manipulate the ground states [2], experiments under hydrostatic and uniaxial pressure are underway.

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LASER SYNTHESIS OF NANOPARTICLES AND THEIR APPLICATION IN PHOTOCATALYSIS

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One of the crucial environmental problems today is water pollution due to rapid industrialization. Organic dyes used by various industries can be toxic and mutagenic for the environment and living beings, so we must find an effective method for their decomposition. One of the approaches is photocatalysis, which is based on oxidation-reduction reactions, which can further decompose any organic pollutant into environmentally friendly products such as carbon dioxide and water [1]. Nanoparticles possess unique physical and chemical properties compared to their bulk counterparts due to their high surface-to-volume ratio. Laser synthesis of nanoparticles emerges as a relatively simple and eco-friendly method with the production of very pure nanoparticles compared to conventional chemical methods [2]. Zinc oxide (ZnO) proved to be a promising photocatalyst in the photodegradation of various organic dyes [3,4]. Coupling ZnO with a noble metal such as silver or gold can enhance photocatalytic efficiency due to the localized surface plasmon resonance (LSPR) [5].

In this work, we will discuss the photocatalytic activity and mechanism of ZnO coupled with noble metal prepared by pulsed laser deposition and pulsed laser ablation method. Furthermore, the characterization of nanoparticles will be addressed.

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