15th - 16th April

11th STUDENT CONFERENCE

Jožef Stefan International Postgraduate School
And 13th Young Researchers' Day
(CMBE-Chemistry, Material, Biochemistry, Environmental)
(Planica – Nordic Center, Slovenia)

Institut "Jožef Stefan"
Ljubljana, Slovenija

Science of the future
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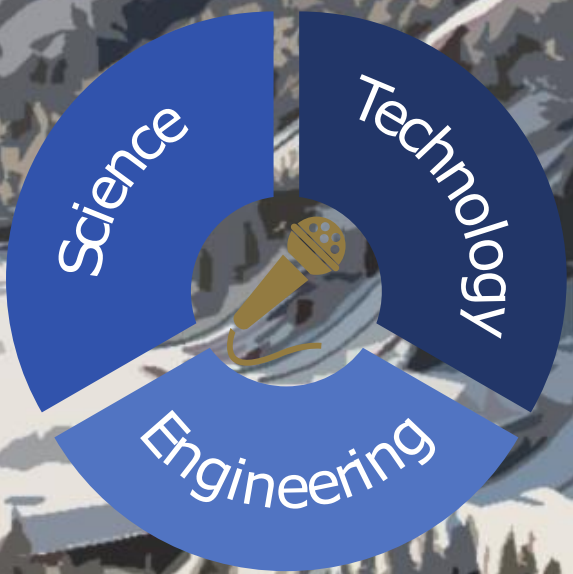

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11. ŠTUDENTSKA KONFERENCA MEDNARODNE PODIPLOMSKE ŠOLE JOŽEFA STEFANA IN 13. DNEVA MLADIH RAZISKOVALCEV (KONFERENCA KMBO)

Knjiga povzetkov

11th JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL STUDENTS' CONFERENCE AND 13th CMBE DAY

Book of abstracts

Uredili / Edited by:

Martin Topole, Timotej Turk Dermastia, Miha Dežman, Blaž Škrlj, Andrea Jurov, Katarina Bačnik, Jasmina Masten, Živa Marinko, Patricia Jovičević Klug, Rok Pahič, Iaroslav Rybkin, Jutra Černilogar, Adem Kikaj,

Založnik / Publisher

Jožef Stefan Institute and Jožef Stefan International Postgraduate School
15. in 16. april 2019, Planica, Slovenija / 15th and 16th April 2018, Planica, Slovenia

Organizacijski odbor / Organizing Committee:

Martin Topole,
Timotej Turk Dermastia,
Miha Dežman,
Blaž Škrlj,
Andrea Jurov,
Katarina Bačnik,
Jasmina Masten,
Živa Marinko,
Patricia Jovičević Klug,
Rok Pahič,
Iaroslav Rybkin,
Jutra Černilogar,
Adem Kikaj,

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prof. dr. Aleš Švigelj,

Končna komisija za oceno prispevkov in predstavitev / Final commission for the evaluation of contributions and presentations:

dr. Marina Dermastia,
dr. Ester Heath,
dr. Tomaž Javornik,
dr. Kristina Žužek Rožman.

ISO-FOOD komisija / ISO-FOOD commission:

dr. David Heath

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Beseda predsednika MPŠ: Akad. prof. dr. Vito Turk

Na Mednarodni podiplomski šoli Jožefa Stefana (MPŠ) je sedaj že petnajsta generacija podiplomskih študentov. Zlasti nas veseli, da se na našo šolo vpisujejo praviloma najboljši slovenski študentje, pa tudi tuji podiplomci. MPŠ se je s svojim kvalitetnim delom uveljavila tako doma kot tudi v tujini in tako postala mednarodno prepoznavna. V vsem tem času je uspešno opravljala svoje poslanstvo, kar kažejo kvalitetna doktorska in magistrska dela. To je rezultat po eni stani uspešnega sodelovanja podiplomskih študentov in njihovih mentorjev, po drugi strani pa možnosti, ki jih nudijo ugledne raziskovalne institucije, ki v tem procesu sodelujejo. Na prvem mestu je treba omeniti Institut »Jožef Stefan«, ki največ doprinaša k uspešnemu delu te šole s povečini sodobno opremo ter širokim izborom kvalitetnih mentorjev. Z vključitvijo Nacionalnega inštituta za biologijo (NIB) in Inštituta za kovinske materiale in tehnologije (IMT) so se še razširili naši potenciali, ki tako prispevajo k še večjim možnostim povezovanja in izkoriščanja razpoložljivih kapacitet – interdisciplinarnosti. Že od ustanovitve našo podiplomsko šolo podpira slovensko gospodarstvo, čeprav bi bila večja finančna podpora, zlasti s skupnimi projekti, več kot dobrodošla.

Očitno je, da moramo stalno ponavljati, da je ključnega pomena za uspešno delovanje v pogojih ekonomske in tehnološke globalizacije stalno spremljanje razvoja znanosti in inovativnosti v svetu. To pomeni, da moramo v vseh pogledih, predvsem pa vlaganjem v znanosti in infrastrukturo posvečati največjo pozornost. Na tem mestu moram omeniti nerazumno podfinanciranje znanosti s strani države, kar nedvomno prizadeva celotno visokošolsko znanstveno delovanje, kot tudi gospodarstvo. Pristali smo pri dnu EU držav s trenutno nekaj več kot 0,40 % BDP državnih vlaganj v znanost, kar nas še vedno uvršča na evropsko dno. Medtem ko že razvite države še naprej pospešujejo vlaganja v znanost in raziskave, manj razvite pa nas dohitevajo in prehitevajo, se v Sloveniji praktično ne dogaja nič oz. ostajamo le pri obljubah ali zavajanjih. Tudi zadnji majhen dvig finančnih sredstev še zdaleč ne obeta izpolnitve koalicijskega sporazuma na dvig 1 % BDP do konca mandata te vlade. To celo pri sedanji gospodarski rasti, ki je med najvišjimi v EU. Enako velja za novi predlog Zakona o raziskovalno-razvojni dejavnosti, ki je že vrsto let v razpravi, občasno tudi miruje, kar pomeni, da ostajamo še vedno pri predlogu. Že samo glede na tako stanje težko enakopravno sodelujemo z razvitimi sredinami, čeprav v to vlagamo ogromno truda. Vse navedeno in še kaj pospešuje ''beg možganov'' že po končanem srednješolskem izobraževanju. Treba je jasno povedati, da visokošolsko izobraževanje ter znanost pripadata danes generaciji brez meja! Danes je beseda "odličnost" postala izjemno popularna v svetu, zlasti na področju znanosti. Za odlično znanost pa morajo skrbeti izključno same države oz. njihove vlade! To razviti zelo dobro vedo. Pri različnih razpisih, še zlasti Horizon 2020, so uspešni le tisti projekti, ki dobijo oceno odlično ali celo izvrstno. Osnovne raziskave s takimi ocenami naj bi vodile s svojimi prelomnimi dosežki

do novih inovacij in proizvodov, od katerih je odvisna ekonomska rast in moč države. Slovenijo, kot tudi mnoge manj in nerazvite države, tare predvsem nizka produktivnost. Rešitev tega problema je le v intenzivnih vlaganjih v raziskave in ljudi. Zato pa je potrebnih veliko naporov in finančnih vlaganj vlad, ki razumejo pomen znanosti in raziskav za razvoj celotne družbe. Le tako bo Slovenija uspešno vzpostavila kvalitetno sodelovanje z industrijo ter razvijala produktivne partnerske odnose. Zmotno je mnenje, da bomo le s sredstvi EU dosegli zaželene cilje. Ker že govorimo o odličnosti, smo pri projektih ERC odličnosti prav pri dnu EU. Glede na navedeno nas ne sme presenečati, da smo priče že prej omenjenemu begu možganov in ne kroženju, kot to željo nekateri prikazovati.

Kljub vsemu naša MPŠ vlaga velike napore za doseganje več kot solidnih, v nekaterih primerih tudi odličnih rezultatov v sicer neprijaznih pogojih na področju raziskovalne in visokošolske dejavnosti. To kažejo objave v mednarodno uglednih in v nekaterih primerih vrhunskih revijah, patentih, kot tudi vrsta domačih in mednarodnih priznanj. Naj omenim še izjemno vzdušje in kolegialne odnose, ki vladajo med podiplomci in njihovimi mentorji. Vse to omogoča kljub veliko vloženemu trudu kar uspešno vpetost v mednarodne povezave, tako v evropskem kot tudi v globalnem prostoru. S svojim delovanjem MPŠ znatno prispeva k hitrejšemu prehodu v družbo znanja.

Tudi letošnja predstavitev raziskovalnih dosežkov vas, naših podiplomcev, je dokaz uspešnosti, kar je posledica talenta in veselja do raziskovalnega dela. Vse to vam omogoča, da se boste ob pomoči mentorjev ter bližnjih sodelavcev razvili v kreativne raziskovalce, na katere bomo ponosni, tako doma kot tudi v tujini. S svojem znanjem boste lahko doprinašali k boljši prihodnosti, kot vam jo ponuja sedanjost. Vso pravico imate, da se uspešno spopadate z izzivi v domačem okolju, ne pa da iščete izpolnitve svojih ambicij in eksistenčnih možnostih z odhodi v tujino. Slovenija je lepa dežela, kar pa ni samo po sebi dovolj! Že večkrat sem izjavil, da je "znanje vrednota, ki omogoča narodu ekonomski razvoj in obstoj". Zato postavimo končno znanost in znanje na tisto mesto, ki kulturnemu narodu pripada! Na prvem mestu so za to odgovorni politiki! Tisti, ki vodijo to državo, bi morali vedeti, da so mladi vrhunski raziskovalci pogoj za uspešen gospodarski in vsesplošen razvoj ter so srce družbe znanja. Očitno so potrebne za to spoznanje globoke družbene spremembe. Vendar bodimo še naprej optimisti.

Beseda dekanje MPŠ: Prof. dr. Milena Horvat (slo)

Izmenjava znanja in izkušenj med študenti in raziskovalci krepi in spodbuja raziskovalno delo, ki je po naravi predvsem interdisciplinarno. Letošnja študentska konferenca se nadaljuje s prakso prejšnjih let, da je treba o znanosti govoriti na način, ki je razumljiv širokemu krogu ljudi. Takšne sposobnosti so neločljivo povezane, zato je program konference namenjen tudi pridobivanju veščin komuniciranja za javnost.

Skupna organizacija dveh tradicionalnih študentskih konferenc; Konferenca študentov MPŠ in Dan mladih raziskovalcev kemije, biokemije, materialov in okolja (KMBO) na Institutu Jožef Stefan se je izkazala za zelo uspešno, letos so se študenti odločili za ponovno sodelovanje. Poleg tega so pritegnili tudi študente izven IJS in MPŠ, kar je zagotovo uspeh organizatorjev konference in celotnega študentskega sveta MPŠ, ki je na različne načine promovirala konferenco. Organizacijo konference v Planici so študenti dobro zastavili, kar dokazuje največja dosedanja prisotnost udeležencev na konferenci. Poleg tega je bilo letos uspešno tudi sponzorstvo konference, kar potrjuje, da partnerji MPŠ in ostali menijo, da je ta konferenca pomembna.

V Sloveniji je komunikacija znanstvenih rezultatov za širšo javnostjo in drugimi deležniki na znanstvenem področju pogosto zanemarjena, čeprav Evropa priznava, da je ta segment ključnega pomena pri prenosu znanja v prakso. Zato so v dejavnosti in zahteve tematskih razpisov za program Obzorje 2020 vključene potrebe po učinkovitih komunikacijskih dejavnostih. MPŠ prav tako priznava pomembnost teh dejavnosti kot sestavni del izobraževalnega procesa in bo še naprej podpirala take pobude.

Izziv ustvarjanja pogojev na MPŠ, kjer lahko študentje opravljajo odlično mednarodno primerljivo znanost, hkrati pa razvijajo svoje ustvarjalne in poslovne spretnosti, je eden glavnih ciljev MPŠ. V sodelovanju s partnerskimi raziskovalnimi institucijami in industrijo bomo še naprej podpirali vse aktivnosti, ki ustvarjajo pogoje, ki omogočajo integracijo MPŠ programov z drugimi slovenskimi in tujimi univerzami, da bi študentom zagotovili najboljše znanje in veščine, ki jih bodo potrebovali v prihodnosti.

Vsem udeležencem študentske konference želim uspešno delo, ki bo ostalo v spominu kot ustvarjalno in prijetno druženje.

Deans words, Prof. dr. Milena Horvat (eng)

The exchange of knowledge and experience between students and researchers strengthens and enhances research work, which is by nature mostly interdisciplinary. This year's student conference continues with the practice of the previous year that it is necessary to talk about science in a way that is understandable to a wide spectrum of people. Such skills are inherent in rare, so the conference program is also dedicated to acquiring the skills of communication to the public.

Joint organisation of two traditional student conferences; Students' IPS Conference and Young Researcher Day in Chemistry, Biochemistry, Materials and Environment (KMBO) at the Jožef Stefan Institute (JSI) proved to be very successful last year, and this year, students decided to work together again. Moreover, they decided to attract also students outside the JSI and IPS, which is definitely the success of the conference organizers and the entire IPS Student Council that promoted the conference in various ways. The organization of the conference in Planica was well perceived by the students, which is demonstrated by the largest attendance so far. Moreover, the sponsorship of the conference was well presented this year, confirming that partners and other stakeholders view this conference as an important one.

In Slovenia, the communication of science results to the general public and other stakeholders is often neglected in the scientific sphere, although Europe recognizes that this segment is crucial in transferring knowledge into practice. This is why the need for effective communication and outreach activities are included in activities and the requirements of Horizon 2020 thematic calls. The IPS also recognizes the importance of these activities as an integral part of the educational process, and will continue to support such activities in the future.

The challenge of creating conditions on IPS, where students can perform excellent international comparable science while developing their creative and business skills, is one of the main objectives of IPS. In cooperation with partner research institutions and industry, we will continue to support all activities that create conditions that enable the integration of IPS programs with other Slovenian and foreign universities in order to provide the students with the best knowledge and skills they will need in the future.

I wish all participants of the student conference a successful work that will remain in memory as a creative and pleasant gathering.

"Science of the future – how to stay up to date with your research!"

Študentski svet

Študentska konferenca Mednarodne podiplomske šole Jožefa Stefana (MPŠ) je letošnje leto že tretjič zapored združena z Dnevom mladih raziskovalcev kemije, materialov, biokemije in okolja (KMBO), kar se je do sedaj izkazalo kot dobra praksa. Z združitvijo konferenc so se seveda strinjali tako Odbor za konferenco KMBO, dekanja MPŠ prof. dr. Milena Horvat kot tudi študentski svet MPŠ.

Zaradi pohval in dobrega odziva udeležencev lanskoletne konference je organizacija konference tudi letos potekala izven Ljubljane. Letošnja lokacija konference je tako postala Planica, kjer ima svoj laboratorij in raziskovalne prostore tudi profesor MPŠ prof. dr. Igor Mekjavić. Tako kot lani smo organizatorji tudi letos poskrbeli za rezervacijo prostorov za prenočitev ter samo organizacijo predstavitvenega in znanstvenega dela. Sprememba lokacije in izvrstna organizacija sta se izkazali tudi v številu prijavljenih študentov, saj je svoje delo letos predstavilo kar 68 udeležencev konference.

Konferenca je potekala dva dni. V tem času so vsi študenti z oddanimi povzetki predstavili svoje delo z »elevator pitch« predavanjem, nato pa so nadaljevali svojo predstavitev dela pri posterjih. Strokovna komisija je ocenila predstavitve in plakate ter podelila štiri nagrade najboljšim udeležencem. Tri najboljše govorce je izbrala tudi publika, koordinator projekta ISO-FOOD, ki deluje v okviru Odseka za znanosti o okolju na Institutu »Jožef Stefan«, pa je podelil nagrado za najboljši prispevek na temo znanosti, ki se ukvarja s hrano. Med predstavitvami so svoj del odpredavali tudi trije vabljeni predavatelji, kjer je vsak od njih predstavil pomembnost biti na tekočem (»up-to-date«) s svojim področjem, pa naj bo to v znanosti ali v gospodarstvu. Predstavnik podjetja Cosylab d. d. dr. Kristjan Anderle nam je predstavil podjetje, njihovo vizijo in vpetost podjetja v znanstvene raziskave ter njihove načrte za prihodnost. Svoje delo na planiškem vetrovniku nam je predstavil tudi prof. dr. Brane Širok, ki nas je peljal na ogled tega izjemnega inženirskega izdelka. Kot zadnji vabljeni govorec pa je svoje delo predstavil tudi prof. dr. Igor Mekjavić, ki v Planici že vrsto let preučuje vplive hipoksičnega okolja na delovanje človeškega organizma ter zmožnost njegove prilagoditve, prav tako pa tudi sodeluje z Evropsko vesoljsko agencijo (ESA), kjer z »bed-rest« simulacijami preučujejo vpliv breztežnostnega stanja na astronavte v vesolju ter možnosti za lajšanje negativnih učinkov le-tega. Udeleženci smo si lahko ogledali tudi njihove raziskovalne prostore.

Letošnjo konferenco je podprla množica podjetij in inštitutov. Soorganizatorji MPŠ so bili tako tudi Institut »Jožef Stefan« (IJS), Nacionalni inštitut za biologijo (NIB), Inštitut za kovinske materiale in tehnologije (IMT) ter Strateško razvojno in inovacijsko partnerstvo – Tovarne prihodnosti (SRIPTOP). Poleg so-organizatorjev pa so nam finančno priskočili na pomoč tudi partnerji in soustanovitelji MPŠ – Kolektor Group d. d., Gorenje d. d., BSH d. d., Telekom d. d., ter podjetja, s katerimi smo že v preteklosti sodelovali – SCAN d. o. o, VWR in OMV Istrabenz. Za pijačo na družabnem večeru je poskrbela pivovarna Omnivar iz Ljubljane,

predavanja pa so posneli Videolectures.net. Sodelavci MPŠ so nam ves čas stali ob strani ter nam aktivno pomagali tako pri organizaciji kot tudi pri iskanju sponzorjev oziroma donatorjev. Brez njihove pomoči nam ne bi uspelo izvesti konference na takšnem nivoju.

Namen konference je bil poleg predstavitve raziskovalnega dela podiplomskih študentov tudi medsebojno povezovanje, izmenjava idej, predlogov in kritik ter sklepanje novih poznanstev in partnerstev med vsemi obiskovalci, kajti le s povezovanjem različnih vej znanosti in seveda znanstvenikov lahko upamo na boljšo prihodnost.

"Science of the future – how to stay up to date with your research!"

Student Council

This year, the Student Conference of the Jožef Stefan International Postgraduate School (IPS) has been united for the third time in a row with the Day of the Young Researchers of Chemistry, Materials, Biochemistry and Environment (CMBE), which has proven to be a good practice so far. The merging of conferences was, of course, agreed by both the CMBE Conference Committee, the IPS Dean Prof. Dr. Milena Horvat, as well as the Student Council of the IPS.

Due to the positive response of the participants of the last year's conference, the organization of the conference was once again held outside Ljubljana. This year's location of the conference has thus become Planica, where the IPS professor Prof. Dr. Igor Mekjavić has his own laboratory and research facilities. In the same way as last year, the organizers also arranged accommodation, in addition to the organization of presentation and scientific work. The change of location and excellent organization also reflected in the number of registered students, as 68 participants of the conference presented their work this year.

The conference was held for two days. During this time, all the students with submitted abstracts presented their work with an elevator pitch and then continued the presentation of their work with posters. The expert committee assessed the presentations and posters and presented four awards to the best participants. Additionally, the audience selected three best presenters and the coordinator of the ISO-FOOD project, which is run by the Department of Environmental Science at the Jožef Stefan Institute, awarded the best food-related science contribution. Three invited lecturers also took part in the conference, where each of them presented the importance of staying up to date with their field, be it in science or in the economy. The representative of Cosylab d. d. Dr. Kristjan Anderle, introduced the company, their vision and engagement of the company in scientific research and their plans for the future. Prof. Dr. Brane Širok presented his work on the Planica wind tunnel and took us to see this exceptional engineering marvel. The last invited speaker was Prof. Dr. Igor Mekjavić, who has been in Planica for many years conducting research on the effects of the hypoxic environment on the functioning of the human organism and its ability to adapt to it. He also cooperates with the European Space Agency (ESA), where they study with bed-rest simulations the impact of the zero-gravity state on the astronauts in space, and the possibilities to relieve the negative effects of it. Participants were also able to see their research facilities.

This year's conference was supported by a multitude of companies and institutes. The IPS co-organizers were also Jožef Stefan Institute (JSI), National Institute of Biology (NIB), Institute of Metals and Technology (IMT) and Strategic Development and Innovation Partnership – Factories of the Future (SRIPTOP). In addition to the co-organizers, the partners and co-founders of the IPS – Kolektor Group d. d., Gorenje d. d., BSH d. d.,

Telekom d. d., and the companies with which we have already collaborated in the past – SCAN d. o. o., VWR and OMV Istrabenz also helped us financially. Omnivar brewery from Ljubljana took care of the drinks at the social dinner, while the lectures were recorded by Videolectures.net. The staff of the IPS have stood by us all the time and have actively helped us both in organizing and in finding sponsors or donors. Without their help we would not have been able to conduct a conference at such a level.

In addition to presenting the research work of postgraduate students, the purpose of the conference was to interconnect, exchange ideas, develop proposals, express constructive criticism, and to make new acquaintances and partnerships among all visitors. For it is only by connecting various branches of science and, of course, scientists that we can hope for a better future.

Ekotehnologija (Ecotechnology)

Analysis of element composition and stable isotope ratios of light elements for characterization of Spirulina food supplements from Slovenian market

Jasmina Masten[1,2], Lidija Strojnik[1,2], Marta Jagodic[1,2], Marijan Nečemer[3], Katarina Vogel-Mikuš[3,4], Nives Ogrinc[1,2]

[1] *Department of Environmental Sciences, Jožef Stefan Institute, Jamova 39, Ljubljana, Slovenia*

[2] *Jožef Stefan International Postgraduate School, Jamova 39, Ljubljana, Slovenia*

[3] *Department of Low and Medium Energy Physics, Jožef Stefan Institute, Jamova 39, Ljubljana, Slovenia*

[4] *Biotechnical faculty, University of Ljubljana, Večna pot 111, Ljubljana, Slovenia*

Spirulina is a good source of vitamins, fatty acids, proteins, minerals and other nutrients and can contribute to human well-being. Spirulina products are among leading dietary supplements in the market [1]. Its quality and safety depend on the production environment. Potential biomarkers can be affected by production location and environmental conditions such as climate change and variability that influence algal growth [2]–[4], but also the stable isotopic composition of carbon, nitrogen, sulfur, hydrogen and oxygen. Geographical origin of microalgae and the authenticity of algal products can be discriminated using these parameters. Also, when cultivated in an open environments Spirulina can be subjected to contamination with toxic trace elements [5]. To our knowledge until now no research on stable isotope ratios and their use on geographical origin determination on Spirulina dietary supplements has been performed.

For this research 47 Spirulina dietary supplement samples were collected from the Slovenian market. The samples originating mainly from China, Hawaii, India, Italy and Taiwan were fresh or dried in powder, tablet or capsule form. Carbon, nitrogen, sulphur, hydrogen and oxygen stable isotope ratios in the samples were determined using Elemental Analysis - Isotope Ratio Mass Spectrometry (EA-IRMS) and high temperature TC/EA-IRMS. X-ray fluorescence (XRF) method was used to determine Spirulina macro- and microelement content and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for trace element content analysis.

Stable carbon isotope values ($\delta^{13}C$) ranged from -32.3 ‰ to -16.7 ‰, $\delta^{15}N$ values ranged from -5.4 ‰ to 13.8 ‰, $\delta^{34}S$ ranged from -1.8 ‰ to 13.8 ‰, $\delta^{18}O$ ranged from 12.9 ‰ to 27.2 ‰ and $\delta^{2}H$ ranged from -208 ‰ to -97 ‰. Elemental concentrations listed according to their values were as follows: potassium > phosphorus > sulphur > silicon > calcium > chloride > iron > strontium > titanium > zinc > rubidium > selenium. The upper safety levels for toxic trace elements such as arsenic (0,3–8,0 µg/kg body weight/day), cadmium (3,0 mg/kg Spirulina dry weight (dwt)), lead (3,0 mg/kg dwt) and mercury (0,1 mg/kg dwt) have not been exceeded [6]. Significant differentiation of samples originating from Hawaii, Italy and Taiwan was found by discriminant analysis (DA) taking into account stable isotope data and elemental composition.

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Analytical technique sniffs out aroma frauds

Lidija Strojnik[1,2], Jože Hladnik[3], Nika Weber[3], Darinka Koron[3], Matej Stopar[3], Emil Zlatič[4], Doris Kokalj[4], Mateja Naglič Gril[5], Tine Grebenc[6], Matteo Perini[7], Silvia Pianezze[7], Federica Camin[8], Nives Ogrinc[1,2]

[1]Department of Environmental Sciences, Jožef Stefan Institute, 1000 Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, 1000 Ljubljana, Slovenia
[3]Department of Fruit Growing, Viticulture and Oenology, Agricultural Institute of Slovenia, 1000 Ljubljana, Slovenia
[4]Department of Food Science and Technology, Biotechnical Faculty, University of Ljubljana, 1000 Ljubljana, Slovenia
[5]R&D Department, Frutarom Etol, 3211 Škofja vas, Slovenia
[6]Department of Forest Physiology and Genetics, Slovenian Forestry Institute, 1000 Ljubljana, Slovenia
[7]Experimental and Technological Services Department, Technology Transfer Centre, Fondazione Edmund Mach (FEM), Via E. Mach 1, 38010 San Michele all'Adige, Italy
[8]Department of Food Quality and Nutrition, Research and Innovation Centre, Fondazione Edmund Mach (FEM), Via E. Mach 1, 38010 San Michele all'Adige, Italy

Flavour is an important quality trait of food and beverages and is determined by taste and aroma. However, the growing demand for natural aromas and the fact that natural raw materials are becoming more expensive is putting increasing pressure on prices and quality. Since synthetic flavourings are often much cheaper than natural ones, adulterating practices with the aim of increased revenue are a concomitant phenomenon in the production of aromas. Gas chromatography-combustion/pyrolysis-isotope ratio mass spectrometry (GC-C/P-IRMS) for the analysis of volatile compounds, sampled using headspace solid phase microextraction (HS-SPME), is identified as an appropriate tool for authenticity assessment of aromas. To verify the authenticity of commercial samples, $\delta^{13}C$ ($\delta^{2}H$) values of different aroma compounds are determined and compared to the authentic range in stable isotope databases. Any sample with one or more compounds outside this range is then suspected of being adulterated. A crucial step for reliable verification of commercial samples, is the creation of databases for flavour compounds from a well-defined origin, allowing comparisons and confirmation of authenticity. Therefore stable isotope databases for apple, strawberry, vanillin, and truffle aroma compounds were established. We characterised 34 apple, and 9 strawberry laboratory produced recovery aroma samples of natural origin, 74 samples of truffles (most of the samples are from T. aestivum and T.magnatum species) and almost 50 authentic samples from vanilla pods. Additionally, we characterised pure synthetically derived characteristic aroma compounds and nature-identical (ex) vanillin samples. Additional types of fruits (peach, blueberry, watermelon, pear, banana, and raspberry) were tested to see if the type of fruit is an important parameter when creating a database of natural compounds. Further, we expanded the apple and strawberry database, including analysis of raw fruit and fruit juices. For most of the selected aroma compounds, we obtained good discrimination between the natural and synthetic authentic range. Finally, commercial samples such as distillates, pure aroma compounds, powder flavoured supplements, flavoured water and food products were tested, including truffle samples from the market. First results of commercial samples show possible falsification for several fruit aroma compounds. Further, the results also showed that all the samples stated to be flavoured with natural vanillin contained synthetic vanillin. Also, truffle samples from the market are suspected of being flavoured with synthetically derived truffle aroma. As these result indicate, significant doubt exists about the authenticity of flavoured products on the market and extensive testing of products is necessary.

Bacterial degradation of plant biopolymers for making highly valuable products

Jutra Černilogar[1, 2], Iaroslav Rybkin[1, 2], Tomaž Rijavec[1], Aleš Lapajne[1]

[1]Department of Environmental Science, Jožef Stefan Institute, Ljubljana, Slovenia

2 Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

Plant biomass is the most abundant renewable biomass on earth and it can be considered as an attractive source for obtaining useful products. It is known that some plants might be invasive and harmful for ambient environment. However, we propose their using and processing by involving different microorganisms for plant decomposition. Such process has a big potential for production of highly valuable compounds such as ferulic acid, vanillin, vanillic acid, etc. from potentially not applicable species.

However, we need to keep in mind about complexity of this system, since plant degradation is not a straightforward process. It is based on the involvement of different strains and enzymes for braking the chemical bonds of biopolymers, such as lignin, cellulose, hemicellulose, starch and inulin and bacterial (cell-to-cell) metabolic cooperation. In addition, it is needed to keep in mind about physiology of plant, where lignin is the most complex compound for decomposition, since it has a large part in the plant biomass and high biological stability.

Hence for the first step, bacterial isolates must be obtained from the plant rhizosphere, roots and decaying wood of invasive species and then transferred to a selective medium containing lignin, cellulose, starch or inulin, where just degrading strains will be able to grow. Secondly, it has been found that several enzymes such as laccase, lignin peroxidase and manganese peroxidase have very high activity to break lignin's bonds. So, these enzymes must be included in the biochemical decomposition when all degrading strains are obtained. Thereby, aims of our work were following: (i) obtaining of cells degrading compounds as lignin, cellulose, inulin and starch and (ii) examination of ligninolytic enzyme activity.

According to our preliminary results, we isolated degrading strains from decayed plant material. By a simple test we confirmed decomposition of all carbon sources by bacteria on agar plates. The genetic material derived from the obtained strains can be considered as a source of enzymes in genetically modified systems.

Challenges in change of paradigm in air quality monitoring – from passive sensing to participatory air quality sensing

Johanna Amalia Robinson[1,2], David Kocman[1]

[1]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

The past decade witnessed a change in paradigm of air quality monitoring with the rise of low-cost sensors [1]. Low-cost sensor technologies enable a dense network of air quality monitoring networks to be established, providing fine grained spatio-temporal data [2]. However, the data is not yet of adequate quality compared to the regulatory data measured in official air quality monitoring sites [3]. The low-cost sensor technologies also enable the involvement of the public to participate in air quality sensing, whether by hosting a stationary sensor unit or carrying a portable unit paired with a smartphone in citizen science type participatory and crowd sourcing projects [4]. Instead of passively consuming air quality data from authoritative sources, they can participate in collecting it. In order for the participants to benefit from the gathered data, challenges exist beyond data quality issues, which for long has been the focus area of scientists [5]. In this contribution, we map the challenges hindering an effective long term involvement of the general public in adapting this technology whether for personal use or for scientific project campaigns based on extensive literature review and our own experiences and research while running such campaigns. These include, but are not limited to; motivation, privacy, data visualization, easy-of-use, meaningfulness, sustainability and hardware/software that is fit for purpose. We believe that taking into account the above mentioned in the campaign and sensor design, in addition to ensuring adequate data quality, would result in successful campaigns and longer term involvement with motivated volunteers while providing meaningful data both for scientists and the general public.

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Deep cleaning of fossil fuels with nano-catalyst

Petra Stražar[1,2], Uroš Cvelbar[1,2]

[1]Department of gaseous electronics, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

Past 20 years we observed increasing demand for clean fuels and substantial reduction of sulphur content [1]. Reasons for that are related to:

- lower maximum concentrations of sulphur determined by many countries to improve air quality,
- fuel cell and other catalytical processes due to catalyst poisoning, corrosion of equipment etc. [2].

Hydrodesulphurization process was discovered in 1930 and is still most common process for desulfurization. In this process, feed is treated with hydrogen gas under high partial pressure (2-20 bar) and high temperature (300-500°C) in the presence of catalyst. Where organically bonded sulphur is converted to H_2S gas [3].

Slovenia limited content of sulphur in petroleum and diesel fuels to 10 mg/kg [4]. To reach lower concentrations we need more rigorous process to remove more persistent species like thiophenes, benzothiophenes and their alkylated derivates. Reactions of thiophenes are more complex and can be converted by two pathways: Hydrogenolysis and hydrogenation. Hydrogenolysis is direct removal of S atom by simultaneous cleavage of C-S bond and formation of C-H bond. Hydrogenation pathway involves addition of hydrogen to the carbon, which leads to removal of S atom from aromatic ring. Generally, both reactions proceed in parallel, however it depends on the nature of catalyst [3].

Most commonly used metals for desulphurization catalysts are nickel, molybdenum, cobalt, rhodium, palladium and platinum. Nickel and cobalt show the best catalytic activity. During process active phase is sulphided and catalytic activity decreases with time according to following reaction: $Ni + H_2S \rightarrow NiS + H_2$. New research show that sulphur can be transferred to oxide support where is permanently stored until regeneration step: $NiS + ZnO + H_2 \rightarrow Ni + ZnS + H_20$ [2].

Aim of my work is to improve conventional catalyst with addition of permanent storage capacity of sulphur and synthesize nano-catalyst that is able to remove sulphur from fossil fuels from 10 mg/kg to 0 and is able to regenerate.

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Development and application of the method for determination of selected licit and illicit drugs biomarkers in wastewater

Taja Verovšek[1,2], Ivona Krizman Matasić[3], Tina Kosjek[1,2], Ester Heath[1,2]

[1]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[3]Rudjer Boskovic Institute, Zagreb, Croatia

Licit and illicit drug abuse represents a major social, economic and health burden. That is why the ability to monitor accurately drug use is of great importance [1]. This is typically done using conventional socio-epidemiological methods such as population surveys, hospital records, crime statistic, sales data (licit drugs), etc. These so-called traditional estimation methods have many weaknesses (time lag in reported data, recall bias, etc.) and there is a need for an alternative approach [1,2]. One such approach is wastewater-based epidemiology (WBE), which is based on the assumption that excreted drug urinary biomarkers are flushed into the municipal sewerage system, where they can be quantified by analysing the raw wastewater. Using this data, and taking into account flow rate, drug excretion profiles, and size of sampled population, collective drug consumption can be estimated [3]. WBE is non-invasive, cost efficient, is able to assess trends in drug use over time, and can provide data in near real-time [1]. Since it provides objective and evidence-based information on drug use, WBE shows great potential to complement traditional epidemiological methods [3].

In this study, a method for determination of 18 urinary biomarkers of four licit (tobacco, alcohol, codeine, and methadone) and six illicit (cocaine, heroin, amphetamine, methamphetamine, ecstasy, and cannabis) drugs in municipal wastewater, was developed. Analyte enrichment was achieved using solid-phase extraction (SPE). The extracts were analysed by reversed-phase liquid chromatography coupled to tandem mass spectrometry (LC–MS/MS). Tobacco and alcohol biomarkers were determined by injecting samples directly onto the LC. Since alcohol biomarkers were poorly retained on conventional reversed-phase chromatographic columns, an ion-pairing agent (TBA, tetrabutylammonium bromide) was added to increase their retention. Accurate quantification was achieved by using 16 deuterated analogues as surrogate standards.

The developed method will be applied to municipal wastewater from five Slovenian wastewater treatment plants. Drug consumption will be estimated [3] and data will be compared with socio-epidemiological studies. Furthermore, wastewater samples will be collected from different education establishments (primary and secondary schools, and universities) in different Slovenian regions, in order to explore consumption patterns among schoolchildren and students, and to compare data based on educational level and geographical location (urban vs. rural).

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Development and validation of a sandwich hybridization-based biosensor for toxic marine diatoms from the *Pseudo-nitzschia* genus

Timotej Turk Dermastia[1], Elisa Villa[2], Janja Francé[1], Delphine Gauillebault[2], Patricija Mozetič[1].

[1]National Institute of Biology, Marine Biology Station, 41 Fornače, 6330 Piran, Slovenia
[2]Microbia Environement, Obs. Océanologique, Avenue Pierre Fabre, 66650 Banyuls sur mer France

Diatoms from the *Pseudo-nitzschia (PN)* genus are a group of phytoplankton organisms that are common members of phytoplankton communities worldwide. In certain conditions, they can proliferate and form blooms that can present a threat to ecosystems and humans through intoxicated seafood ingestion. This is due to the ability of some species in the genus to synthesize a potent neurotoxin called domoic acid. Thus, monitoring schemes have been developed all over the world for the detection of both phytoplankton cells and their toxins. Identification and enumeration of cells requires trained taxonomists, which are often not available to aquaculture operators and public officers. Furthermore: 1) information of cell abundance in environmental samples does not give insight into cell activity by which we can predict the stage of the bloom the cell population is in; 2) dead or dying cells often cannot be distinguished from living ones, especially in fixed samples. In this contribution, we developed a simple sandwich-hybridization assay that detects *PN* specific RNA in environmental samples. RNA deteriorates in the environment quickly and its concentration is thus a proxy for the number of living and active cells. The assay was validated against cultured specimen of seven *PN* species that have been previously identified. RNA from cultured species was tested for probe specificity on a patented microarray and the probes that showed to be the most specific were selected for microplate coating. Tests on microplates are quicker and cheaper to conduct and allow more samples to be processed compared to microscopy. Detection limits for the selected probe-species pairs were established using RNA from cultured species. The assay resulted in signals for most species at around 5-10ng RNA, which is equivalent to around 1000 cells per litre. We also tested the assay's performance on a long series of environmental samples that were previously validated by light microscopy counting. Since most species of *PN* are impossible to identify using light microscopy, counts are usually reported for the entire genus or at best for two morphological groups within the genus. Occasionally, identification to the species level in natural samples was also provided which enabled us to test the assay for these species. We are able to report good coherence between microscopic counts and sensor output. These two methods are complementary and provide deeper insight into the biology of the bloom. For better result interpretation, additional factors such as toxin production should be also taken into account. The analysis time of the sensor is 2-3 hours, which is very efficient and allows the analysis of 80 samples at the same time. Further work will include improving the assays performance by testing additional cultured strains as well as negative targets. Preliminary results on other HAB species with a novel protocol showed increased sensitivity by a factor of 10.

Ectodomain shedding of epidermal growth factor receptor by cysteine cathepsins

Marija Grozdanić[1, 2], Barbara Sobotič[1], Matej Vizovišek[1], Boris Turk[1, 2, 3, 4] Marko Fonović[1,4]

1 Department of Biochemistry, Molecular and Structural Biology, Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
2 Jožef Stefan International Postgraduate School, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
3 Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia
4 Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins, Jamova cesta 39, SI-1000 Ljubljana, Slovenia

Cysteine cathepsins are lysosomal proteases which are also known to be secreted to the extracellular space. Secreted cysteine cathepsins can cleave ectodomains of membrane proteins including receptors, growth factors, cytokines and adhesion proteins. Among the receptors, epidermal growth factor receptor (EGFR) was identified as cathepsin substrate candidate with high physiological relevance. Signalling through EGFR is commonly triggered by ligand binding, however, deletions in extracellular region of EGFR can also cause constitutive activation which is ligand independent. Such deletions can influence receptor activation and downstream signalling cascades such as phosphatidylinositol 3 ON (PI3K) pathway. Here we report that cathepsin L proteolyticaly cleaves domain II of EGFR and that this cleavage causes its activation and influences its physiological function. Using an engineered ectodomain deletion which emulates the cathepsin cleavage of EGFR, we have shown that such cleavage affects phosphorylation profile of cellular kinases. Our results also indicate that the presence of truncated EGFR in cancer cells, triggers an alteration in the expression of profilin 1, an actin-monomer binding protein that is involved in several cellular processes, such as cell cycle and proliferation.

Groundwater and milk – geographical origin in the production area of Parmigiano Reggiano: validation with the isotopic analysis

Marta Boito[1], Paola Iacumin[1], Nives Ogrinc[2]

[1]Dipartimento di Scienze Chimiche, della Vita e della Sostenibilità Ambientale, Università degli Studi di Parma
[2]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia

The stable isotope ratios ($^{13}C/^{12}C$, $^{15}N/^{14}N$, $^{87}Sr/^{86}Sr$, $^{18}O/^{16}O$, $^{2}H/^{1}H$) of animal feed (hay and fodder), groundwater and milk were monthly investigated, considering cows in ten cattle-shed belonging to the "Consorzio del Parmigiano Reggiano" over a period of one year that are fed with diets made up of different kinds of C3 plants and different amounts of maize.

The Protected Designation of Origin (PDO) trademark has been assigned to numerous local products based on their area of origin. In order to obtain this designation, the raw materials must have been produced and processed in the specific region from which the product gets its name [1] [2].

The main aim of the investigation is the evaluation of the dependence of the isotopic composition of milk on food and water ingested by the cow and define the isotopic fractionation of water ingested/milk produced and milk produced/food supplied.

The $^{18}O/^{16}O$ and $^{2}H/^{1}H$ isotope ratios of milk reflect the isotopic ratios of the animal diet and the drinking water that depend on the local environmental conditions.

The isotopic analysis allowed to differentiate the milk produced in different areas from animals with different diets according to organic or conventional production schemes [3].

From the first results obtained it was possible to notice a differentiation of the isotopic values of O and H between plain and mountain milk and a correlation between water and milk values belonging to the same cattle-shed. Even, the hay produced locally by breeders is different compared to the one purchased by import indicating that these parameters can increase the added value of producer's cheese.

Determination of the geographical origin of foodstuffs is becoming of increasing interest to consumers and producers and overall results of the present study can be used to verify the possibility of discriminating the milk produced in different places on the basis of isotopic ratios. This is might be used to develop a model for the traceability and to protect against commercial frauds [3] [4].

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Long-term variability of the phytoplankton community in a highly variable coastal sea (Gulf of Trieste)

Ivano Vascotto[1,2], Janja France[1], Patricija Mozetič[1]

[1]National Institute of Biology, Marine Biology Station Piran, Fornače 41, 6330 Piran, Slovenia
[2]Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

Abstract

The shallow and land-surrounded north-eastern Adriatic Sea has seen a change in terms of environmental drivers in the last decades [1]. These were in turn reflected in seasonal and inter-annual variability of phytoplankton community, which was already described in this area [2]. However, the fine-scale community structure at species/genus level still lacks the connection to driving forces. Here the structural changes in the phytoplankton community from a LTER station in the Slovenian coastal sea (2005-2017) have been analyzed using a statistical method based on hierarchical clustering and Bayesian probability following the method proposed in literature [3]. The monthly probability distribution of assemblages and the inter-annual succession patterns were obtained. Each sample was then allocated in a group using its sampling date and its group associated probability. Then, using this temporal composition model as grouping factor, the IndVal index was calculated [3] and the typical community for each group was obtained [4, 5]. Six groups of phytoplankton taxa were identified and their distribution through years has been described. The methodology seems to show a relevant improvement in terms of classification fit in comparison of using months as grouping factor.

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Acknowledgements:
Thanks to Milijan Šiško for the help in compiling R.

Provenance of milk samples from different regions in Slovenia: Strontium stable isotope ratios

Staša Hamzić Gregorčič[1,2], Nives Ogrinc[2], Tea Zuliani[1,2]

[1]Jozef Stefan International Postgraduate School, SI-1000 Ljubljana, Slovenia
[2]Jozef Stefan Institute, Department of Environmental Sciences, SI-1000 Ljubljana, Slovenia

Variations in geographical, topographical, climatic and geological conditions in the earth's biosphere result in spatial and temporal distributions of the ratios of stable isotopes in environmental matrices. For the establishment of isotope reference maps (*isoscapes*) and databases for isotope-based studies, different isotope systems with different potentials can be used [1]. The use of isoscapes based on Sr isotope ratios, in contrast to the oxygen and hydrogen isotope systems, has the advantage of a low temporal variability of strontium ($^{87}Sr/^{86}Sr$) isotope ratios due to the formation time of billion years for ^{87}Sr. In the last decade, the $^{87}Sr/^{86}Sr$ isotope ratio was used to determine the geographical origin of different foodstuffs, also of dairy products like cheese and butter [2]. Nonetheless, a limited number of studies on the suitability of the $^{87}Sr/^{86}Sr$ isotope ratio determination in milk were published. Reason for this is two-fold. First, the origin of animal feed may not be the same as the farm location. Second, milk is a complex matrix, which contains a great variety of inorganic as well as organic (fat) that make the determination of Sr isotope ratio a challenging task. Therefore, the first aim of this study was to optimize the analytical method for the determination of $^{87}Sr/^{86}Sr$ isotope ratios in milk by multi-collector inductively coupled mass spectrometer (MC-ICP-MS). In order to assign a precise value of the $^{87}Sr/^{86}Sr$ isotope ratio to an agricultural area, a database made by an adequate number of samples representative of the area is required. As in Slovenia and the nearby region no such data exist, we aimed to construct a database of Sr isotopic composition in milk from production areas located in Slovenia using the optimized analytical method.

In this study, 80 samples of cow's milk from 22 different farms around Slovenia were tested. The samples were taken seasonally, in summer and winter in 2014. Total Sr concentrations in the milk samples were in the range from 1.0 to 3.5 mg kg^{-1}. The $^{87}Sr/^{86}Sr$ values in the milk samples range of 0.70867 to 0.71725 for both seasons. The results also showed that the $^{87}Sr/^{86}Sr$ isotope ratios of milk samples of certain areas are comparable for both seasons, except for samples from Dravograd, Murska Sobota, Logatec, and Žužemberk where differences in isotopic composition were observed. These differences are probably due to the source of the cow's diet, which is not necessarily from the same region where cattle graze. However, the determination of Slovenian milk provenance is a complex task that needs further investigation. Additionally, the combination of the results of the multielement and strontium isotopic composition could provide a better discrimination tool to identify the geographical origin of milk products.

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Radon-based method to assess atmospheric stability under winter conditions in Ljubljana

Dafina Kikaj[1,2], Janja Vaupotič[2]

[1]Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

[2]Jozef Stefan Institute, Department of Environmental Sciences, Jamova cesta 39, 1000 Ljubljana, Slovenia

Radioactive noble gas radon is a convenient indicator of atmospheric stability because of its unique properties. It originates in the ground by α-transformation of ^{226}Ra in the natural radioactive chain of ^{238}U and has small spatial and temporal variations. From the ground, it exhales into the lower atmosphere where its activity concentration shows hourly, daily, synoptic and seasonal variations. These variations are influenced by meteorological parameters. Its elimination from air is only by α-radioactive transformation ($t_{1/2}$=3.82 days). Its half-life, which is shorter than the synoptic timescales (≤2 weeks), prevents radon to accumulate in the atmosphere, thus making it an indicator of air masses origin. On the other hand, its half-life is much longer than mixing timescales (≤24 h) of the lower atmosphere. Recently, atmospheric radon was used as a tool to measure the tendency of the lower atmosphere to suppress or enhance the so called atmospheric stability. Understating changes in atmospheric stability is prerequisite to characterize and evaluate air pollution, which has become a major global environmental issue.

The radon activity concentration has been continuously monitored, using an AlphaGUARD radon monitor (Bertin Instruments, Germany), set up in a weather instrument shelter, 1.5 m above the ground at the Ljubljana Bežigrad Meteorological Station. On the basis of radon activity concentrations obtained in winter periods of Dec 2016–Feb 2017 and Dec 2017–Feb 2018, an atmospheric stability classification has been built up. From the quartiles range of radon activity concentrations, five atmospheric stability classes are defined, representing condition of the atmosphere: class 1 (mixed), class 2 (near-neutral), class 3 (weakly stable), class 4 (moderately stable) and class 5 (strongly stable). Because of the complex landscape of the Ljubljana basin, favouring often persistent temperature inversions in winter time, an additional class 6 was added, aimed at reliably representing these conditions [1]. Classes 1, 2 and 3 represent the windy conditions associated with overcast and precipitation, classes 4 and 5 calm conditions with clear sky and no precipitation, and the class 6, calmest and foggy conditions.

The atmospheric stability classification obtained with this procedure, has been tested with particulate matter (PM_{10}). PM_{10} concentration has appeared to correlate well with the stability classes. Concentrations of PM_{10} increased by a factor of 5 from class 1 (days with mixed conditions) to class 6 (days with persistent temperature inversion). This kind of air stability classification will be tested also with some other air pollutants (e. g. BC, CO, CO_2, NO_2, SO_2, O_3 and Hg).

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Reactivity of Imidazolium Fluoride reagent with Trimetylaluminium

Evelin Gruden[1,2], Gašper Tavčar[1,2]

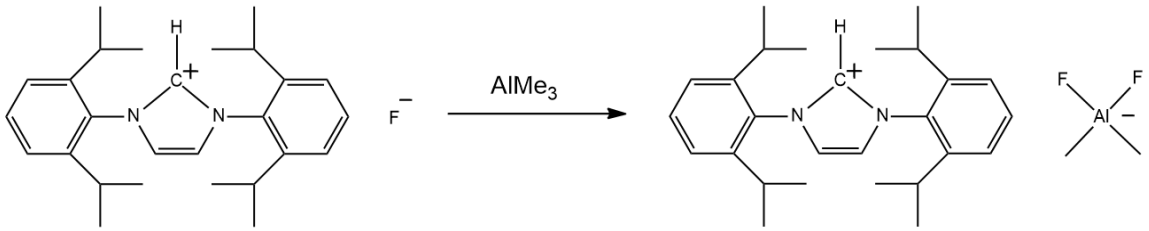
[1]Jožef Stefan Institute, Department of Inorganic Chemistry and Technology, 1000 Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, 1000 Ljubljana, Slovenia

Imidazolium fluoride [IPrH][F] (1,3-bis(2,6-diisopropylphenyl)imidazolium fluoride) is a compound, which has the ability to act as a free fluoride reagent. It was first prepared in our laboratory in 2016 [1]. Its utility as a fluoride donor has been tested and as a result of specific steric and electronic properties of bulky imidazolium cations, first examples of discrete $[GeF_5]^-$ and $[VOF_4]^-$ anions have been prepared [2,3].

Recently we tested the use of [IPrH][F] reagent for the fluorination of various aluminium compounds and gained some interesting results involving trimetylaluminium ($AlMe_3$). According to the literature, fluorination of trialkylaluminium (AlR_3) is achieved by using hydrogen difluoride anion $[FHF]^-$ containing reagents (i. e. $[nBu_4N]HF_2$ and $[Me_4N]HF_2$) [4,5]. In general, the reaction of metal alkyls (MR_n) with $[FHF]^-$ anions leads to the formation of organometallic fluorides ($MR_{n-x}F_x$) upon evolution of alkanes (RH). In the case of AlR_3, the formation of difluorodiorganoaluminates $[R_2AlF_2]^-$ occurs. Organometallic fluorides involving group 13 elements have been known since 1955, but up to date only 3 difluorodiorganoaluminates have been structurally characterized [4,5].

During our work, we managed to prepare a discrete tetrahedrally coordinated $[Me_2AlF_2]^-$ anion associated with bulky $[IPrH]^+$ cation by the use of [IPrH][F] reagent and $AlMe_3$. The newly prepared compound $[IPrH][Me_2AlF_2]$ has been characterised by NMR spectroscopy and single crystal X-ray structure analysis. This result also shows the importance of [IPrH][F] as versatile and applicable fluorination reagent.



Sheme 1: Syntheses of $[IPrH][Me_2AlF_2]$.

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Removal of bisphenols in lab-scale algal bioreactors

David Škufca[1,2], Franja Prosenc[3], Ana Kovačič[1,2], Marilyne Pflieger[3], Tina Kosjek[1,2], Tjaša Griessler Bulc[3], Ester Heath[1,2]

[1]Department of Environmental Sciences, Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana
[2]Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana
[3]Faculty of Health Sciences, University of Ljubljana, Zdravstvena pot 5, 1000 Ljubljana

Introduction. Bisphenol A (BPA), a known endocrine disrupting compound, is used in the production of plastics and resins. Alternatives to BPA, collectively known as bisphenols (BPs), share the same basic structure and there is now growing concern about their potentially harmful effects. Wastewater presents the main influx of BPs into our environment. Algal wastewater treatment may present an opportunity to treat wastewater with simultaneous nutrient recycling. Reclaimed water could be used in irrigation or as greywater. Algal biomass may be reused as feed supplement, fertilizer or biofuel feedstock. Developing such reuse patterns would result in a circular economy, with minimal amounts of nutrients and pollution released into the environment. Our current aim is to study the removal of 17 BPs in laboratory-scale algal bioreactors.

Methods. Batch algal bioreactors were incubated under fluorescent Osram Fluora lights with a 16:8 (light:dark) photoperiod for 9 days. During operation, the bioreactors were constantly shaken at 150 rpm and temperature, pH, conductivity, oxidation-reduction potential, O_2 saturation, and cell count were regularly monitored. Nutrients in the form of total nitrogen and total phosphorus were measured at day 0 and day 9. After centrifugation and filtration, residual BPs were extracted using Oasis Prime HLB SPE cartridges. Samples were then derivatized with N-Methyl-N(trimethylsilyl)trifluoroacetamide and the catalyst pyridine and subsequently analysed with GC-MS.

Results. Algae cell count grew from 3.2×10^6 cells/ml at the beginning of the experiment to 2.6×10^7 cells/ml after 9 days, meaning an approximately 8-fold increase in cell density. Relative removal of BPs from water ranged from 9.4 ± 3.9% (BPS) to 98.5 ± 0.1% (BP26DM), depending on the compound. Removal was found to correlate with partition coefficient K_{ow} indicating that adsorption and/or bioaccumulation may play a key role in the removal of these pollutants. Additionally, tentative evidence points to abiotic degradation of certain compounds.

Future work. We aim to develop a method for the extraction of BPs residues in the algal biomass to assess the amount of BPs accumulated in the biomass. We also plan to improve the removal of recalcitrant BPs by inoculation of a suitable bacterial consortium, creating a symbiotic algal-bacterial system. Finally, we intend to assess the distribution (mass balance) of BPs in the algal bioreactors.

Speciation of Ruthenium-based complexes in human serum by conjoint liquid chromatography on monolithic columns

Katarina Marković[1,2], Janja Vidmar[1], Stefan Marković[1,2], Iztok Turel[3], Jerneja Kladnik[3], Janez Ščančar[1,2], Radmila Milačič[1,2]

[1]Department of Environmental Sciences, Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Jamova 39, SI-1000 Ljubljana, Slovenia
[3]Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večna pot 113, SI-1000 Ljubljana, Slovenia

There is estimation that 3.9 million of people in Europe were diagnosed with cancer in 2018. Cancer is second cause of death in Europe, after cardiovascular diseases. For its treatment, Pt-based chemotherapeutics are commonly used in medicine for more than thirty years, with many flaws such as severe side effects and development of resistance. In order to improve anticancer treatment Ru-based chemotherapeutics are synthesized. Two complexes are already in third phase of clinical trials NAMI-A (trans-[imH][$RuCl_4$(dmso-*S*)(im)] and KP1019 (*trans*-[indH][$RuCl_4(ind)_2$], which shown to have less side effects with lower resistance. In this study we used newly synthetized Ru complexes: RuPthCl and RuPthPTA. RuPthCl complex is potentially multitarget drug which showed inhibitory effects on enzymes acetylcholinesterase and glutathione-S-transferase in human and horse serum, without cytotoxic effects on non-transformed cells at pharmaceutically relevant concentrations. [1,2]

For preclinical and clinical trials of Ru-based complexes, it is important to study pharmacokinetics of administrated drug in human serum and interactions with serum proteins. One of the possibilities to provide this information is utilization of chemical speciation analysis. [3]

In this study, intact Ru-based complexes were separated from their species bound to serum proteins by using monolithic columns with convective interaction media (CIM) disks hyphened "on line" with ultraviolet detector (UV) and inductively coupled plasma mass spectrometer (ICP-MS). [4,5] CIM monolithic columns were composed of two different disks in a single housing, CIM Protein G as affinity disk for separation of immunoglobulin (IgG) and CIM diethylamine (DEAE) as weak anion-exchange disk for separation of intact drug from drug attached to transferrin (Tf) and human serum albumin (HSA). These monolithic columns enabled two-dimensional separation in one chromatographic run. [6] Serum proteins eluted from monolithic columns were detected on-line by UV detector at 278 nm, while elution of Ru species were followed by ICP-MS and accurately quantified by post column isotope dilution ID-ICP-MS technique. For this purpose, Ru was monitored at m/z 101 and 99.

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Tracing of uranium isotopes in Ljubljanica River catchment

Leja Rovan[1,2], Ljudmila Benedik[1,2], Marko Štrok[1,2]

[1]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

Accurate and precise determination of uranium isotope ratios have many important applications in studying redox conditions, chemical weathering and mixing processes in hydrologic and marine systems. The main mechanisms controlling uranium isotopic fractionations are its variable solubility present in different redox states and the alpha recoil process. In freshwater environments in continental areas with predominantly carbonate lithology, isotopic studies of uranium can reveal the water composition and redox conditions. To detect these smallest amounts of isotopes and to have high accuracy in order to differentiate between small fractionations in natural uranium samples, this can be achieved only by using advanced analytical tools, such as multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS).

Measurements of uranium isotope ratios ($^{235}U/^{238}U$ and $^{234}U/^{238}U$) were carried out with Nu plasma II, (Nu instruments Ltd, UK) MC-ICP-MS with the high-efficiency sample introduction system Aridus II™ (Cetac Technologies, NE, USA). For assessing uranium concentrations, a single collector mass spectrometry an Agilent 8800 Triple Quadrupole ICP-MS (ICP-QQQ) (Agilent Technologies, Tokyo, Japan) was used. Instrument mass bias was corrected with external standard – sample – standard bracketing technique. Measured uranium isotope ratios were calibrated against corresponding uranium isotope ratios in certified uranium standard IRMM-184 that had been measured before and after the applying sample.

Analyzed samples were collected from karstic aquifer of Ljubljanica River from different time periods, with focus on water at springs, sinks and within the aquifer in accessible caves to allow studying temporal and spatial variations. Optimization of MC-ICP-MS established good accuracy and precision in detection small uranium isotopic variations, which permits the tracing of riverine uranium in very low concentrations. Results of uranium isotopic composition from different sampling campaigns, show variations for some sampling sites between sampling campaigns and between samples and natural uranium standard. Uranium isotopic composition shown promise as a tracer of water sources in stream waters at the catchment scale. Uranium isotope ratios can be also used to trace seasonal variation along the flow path of karstic water through consecutive sources and sinks, due to significant difference in uranium isotopic composition between dry and flood seasons.

United tiny fabrics as the future for new metabolic pathways

Iaroslav Rybkin[1,2], Tomaž Rijavec[1], Jutra Černilogar[1], Aleš Lapanje[1]

1Jozef Stefan Institute, Ljubljana, Slovenia
2Saratov State University, Saratov, Russian Federation

Obtaining new valuable products by using the biotechnological processes has tremendous potential due to the possibility of the involvement of various microorganisms and formation of new joint metabolic pathways. To maintain such a complex system cells must share decomposed products within developed pathways, where one of the key factor is cell to cell interaction depending on the activity of the bacterial surface.

Modifying the last enables us affecting the process of attachment to different surfaces, can induce formation of homo- or heterocellular aggregates, attachment of enzymes for faster start-up of bioreactor processes or keeping the desired surface charge. From simple physical point of view, cells can be considered as negatively charged inanimate "particles" due to composition of cell wall, which includes such elements as: phospholipids, proteins and polysaccharides. So, bacteria are shown to be convenient template for polyelectrolyte deposition via electrostatic interaction.

However, cells are not simple as inorganic particles and electrostatic approach is not straightforward as might be considered. Small size of bacteria, fast division rate and presence of many appendages complicate the method of deposition. Cells can act as fluid structures forming spatial random-sized uncontrollable aggregates being exposed to polymers. In addition, complexity of the cell surface structure and activity of cell wall, which is involved in bacterial cell respiration and the transporting of different molecules, bring additional severities to the procedure of deposition.

Hence, appropriate covering can be achieved by development of the most efficient method of polymer deposition combining basic physicochemical principles on the one hand and on the other, keeping in mind the physiology of the particular type of bacteria.

Therefore, our aims were to determine: (i) the interference of the growth stage of the culture on the efficiency of deposition of polyelectrolytes on the surface of the individual alive bacterial cells, (ii) the response of the bacterial cells after the polyelectrolyte nano-sized layers were formed on their surfaces (iii) and the growth properties of interspecies aggregates with joint metabolic pathways

According to our results, bacterial cells, entrapped in polyelectrolyte shells, staying alive but have delayed cell growth, caused by the mechanical restriction of individual cells, since we did not observe any kind of toxic effects on *Escherichia coli*. In addition, we showed how different cells survive the encapsulation process. We also proved that such modified cells showed tremendous ability to attach to different sorts of surfaces or control intercellular interactions between different bacteria.

Virus inactivation in water by plasma

Arijana Filipić[1,2], Tadeja Lukežič[2], Magda Tušek Žnidarič[2], Gregor Primc[3], Rok Zaplotnik[3], Nataša Mehle[1], Ion Gutierrez-Aguirre[1], Maja Ravnikar[1,4], Miran Mozetič[3], David Dobnik[1], Jana Žel[1]

[1]National Institute of Biology, Department of Biotechnology and Systems Biology, Večna pot 111, 1000 Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

[3]Jožef Stefan Institute, Department of Surface Engineering and Optoelectronics, Jamova cesta 39, 1000 Ljubljana, Slovenia

[4]University of Nova Gorica, Vipavska 13, 5000 Nova Gorica, Slovenia

An increasing number of biotic and abiotic pollutants is only one of the reasons why lack of clean and safe water is one of the biggest problems we have to face today. The possibility of viruses being transmitted through water was neglected for decades, however, this notion is changing consequently to the rising number of waterborne human and plant diseases that are emerging due to suboptimally disinfected water. Many water transmissible viruses are infectious in low dosage, stay infectious after long periods of time and can cause a whole plethora of diseases. For this reason, inactivation of viruses in water is extremely important. Since all the methods currently used for water decontamination have some negative properties, the search for alternative methods became very important. One such method that is environmentally friendly, easy to use, non-toxic, and could thus be used for water decontamination, is cold atmospheric plasma.

Plasma is the fourth state of matter. Like gas, it does not have a fixed shape or volume, but its composition is much more complex. It consists of charged particles (i.e., ions, free electrons), reactive species, ultraviolet (UV) photons, and neutral particles (i.e., molecules, atoms in the excited or ground state). Since some of these constituents can successfully inactivate microorganisms, various research groups worldwide are utilizing plasmas for this purpose. Cold atmospheric plasmas are generated under atmospheric pressure and have a temperature of less than 40°C. That is why they can be used for treating biological samples.
In our work, we used cold argon plasma for inactivation of two morphologically different viruses in water samples: potato virus Y (PVY) and bacteriophage MS2, both of which can be successfully transmitted by water. PVY is a filamentous virus that can infect different plants but is the most important potato virus pathogen. MS2 is an icosahedral virus, used as a surrogate for enteric viruses transmitted by water. Compared to PVY, its genome is almost three times shorter. We determined success and a mode of virus inactivation with different methods: infectivity tests with either test plants or double layer plaque assay, polymerase chain reaction (PCR), real-time PCR, droplet digital PCR, transmission electron microscopy and optical emission spectroscopy.

Despite the differences between the two model viruses used, we were able to inactivate or sufficiently decrease the concentration of both viruses in 10 ml water samples after very short treatment times including only 1 minute, depending on the treatment properties. We also proposed reactive oxygen species as the main mode of viral inactivation. Our results indicate that plasma could be a powerful tool for solving the

problem of water scarcity as it could efficiently inactivate pathogenic microorganisms and with that make water safer for everyone.

Informacijske in komunikacijske tehnologije (Information and Communication Technologies)

Automated Baremetal Provisioning for Embedded Devices

Ivan Boškov[1,2], Matevž Vučnik[1,2], Carolina Fortuna[2], Mihael Mohorčič[1,2]

[1] International Postgraduate School Jožev Stefan, Ljubljana, Slovenia
[2] Department of Communication Systems, Jožev Stefan Institute, Ljubljana, Slovenia

With the recent increase in development of Internet-of-Things (IoT) devices and their implementation in various fields such as smart homes, smart factories, smart cities, eHealth and much more, certain problems start to emerge. These challenges are centred around the configuration and communication of these devices which may lack a human-accessible input/output capabilities. Nowadays the number of the deployed things in a specific environment may exceed hundreds, which leads to longer configuration time for each device to communicate with each other or to a centralized server.

The idea of this study was motivated by the amount of time that is lost due to long configurations and potential errors in the configuration for IoT devices that are meant to be functional and easy to use out-of-the-box. We created a software that automates the configuration procedure for IoT devices reducing the required time and minimizing the probability for errors by eliminating the need of unnecessary human interaction, as well as providing ease of use and functionality out-of-the-box. Various automation services allow us to achieve configuration times of approximately a minute or less.

Using everyday devices like smart phones or laptops we can essentially extend the user interface of an IoT device which in return allows us to facilitate certain parameters as to how the device should behave. An example of use case is the connection to an internet network, since most IoT devices lack input/output capabilities this means that more often than not the connection is wireless, so by wirelessly connecting the device to a smart phone or a laptop we can facilitate the network parameters as well as the type of security to the device, through the keyboard and display of that smart phone or laptop. There is no limitation as to which technology can be used to deliver the credentials, meaning it can be done by Bluetooth, NFC or Wi-Fi, however depending on the scenario, one technology may be more suitable than the others.

By initializing the network credentials of an IoT device through a remote device we have established an internet connection to the thing, effectively deploying it the network.

Data Driven Link Quality Estimation

Gregor Cerar[1,2], Mihael Mohorčič[2], Carolina Fortuna[2]

[1]Jožef Stefan International Postgraduate School (IPS)
[2]Jožef Stefan Institute, Department of Communication Systems (E6)

Wireless communication became an essential part of our everyday life and we have taken it as granted. Frequently used technologies e.g. LTE, Wi-Fi provide good communication experience, thanks to a highly sophisticated base stations, which are "always-on" and connected to the Internet. With use of time, space and frequency multiplex, these technologies can achieve high throughput and low latency.

What went mostly unnoticed are sensor networks. These are the engine of Industry 4.0. They are low-power constrained devices, loaded with sensors, battery and optional opportunistic energy harvesting strategies. They collect and hold data, provide machine-to-machine communication and their focus is autonomy. The fact is that most energy is consumed by the transceiver.

The idea of sensor node is to operate in opportunistic manner by sending data on constant time period or at certain events. Because of their constrained low-power radio, they are in no position to compete with other technologies. It may take several retransmissions and increases of output power in order to packet successfully reach desired destination. One way to reduce number of retransmission, and therefore preserve energy, is link quality estimation (LQE). If we are able to predict link quality, we could adapt robustness of protocol, change frequency band or path, or even postpone transmission, in order to mitigate issues and improve success rate.

LQEs can have different goals, which are typically related to success ratio or energy consumption. There are multiple ways to build an estimator, which range from purely theoretical approach (propagation, predetermined statistical models) to purely data-driven approach (on-site data gathering). The focus of our research is data-driven estimation using machine-learning (ML). During research, we used freely available dataset from Rutgers university, which was recorder on actual nodes.

During the research [1] we built data-driven ML pipeline, where we tweaked its different stages. We tried different interpolation methods, feature engineering, different resample strategies, various historical and prediction window sizes, and finally several "shallow" machine learning algorithms. The highest jump in performance was caused by selection of "zero-padding" interpolation method. Slightly smaller impact was made by synthetic features, with exception of polynomials, which have degraded performance in all cases. Slightly less improvement was contributed by random oversampling strategy and finally only minor differences between logistic regression, decision trees, random forest and multi-layer perceptrons.

We will continue to improve estimation process by taking leverage of possible candidates quantile features, embedding time series methods and generalization estimators for their usability in for constrained wireless nodes.

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Deep encoder-decoder network for learning to write digits with a humanoid robot

Rok Pahič[1,2], Barry Ridge[1], Aleš Ude[1]

[1]Department of Automation, Biocybernetics and Robotics, Jozef Stefan Institute, 1000 Ljubljana, Slovenia

[2] Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

While acting in an environment, humans mainly rely on their vision because it carries most information. To cooperate with humans and to reach a human comparable performance, robots also need to make use of the visual input. Connecting a motion of a robot with visual input is not only necessary for a robot task performance, but is also suitable for transferring knowledge between a human and a robot. A robot could learn skills directly from a human or recognize his/her intentions by observing the performed movement or the outcome of his/her action. Such an ability could result in an easy-to-use and intuitive human-robot interface.

Visual input is rich with information but it is relatively complex. That makes hand-designing algorithms for connecting visual information to movements very difficult, especially in more demanding robot tasks. Deep learning based on deep neural networks provides a promising alternative to hand-designed algorithms. It showed remarkable capabilities in the field of speech and vision recognition, and it also shows promising results in the field of robotics. Deep neural networks consist of artificial neurons that are connected to other neurons through weights. These weights change while the network is learning to minimize the desired criterion function that measures the performance of the network. The most common approach to optimize the weights is backpropagation, which propagates the error from the criterion function through the neural network by using gradients of the functions defined by the neural network. During the training process, the neural network should learn to generate a correct output for any given input. In supervised learning, this is done using a training database with pairs of the desired input and output.

In our work, we learned a deep encoder-decoder network to generate the movement trajectory for writing digits that reproduce digits contained in input images. Thus the input to the neural network are the values of image pixels and the output are the parameters of a dynamic movement primitive (DMP), which represent the writing trajectory. For learning the weights of the neural network, we created a synthetic database of image and trajectory pairs. For each example, we have varied the angles, length and shape for the digit trajectory and then created the corresponding image. The easiest way to define the criterion function for training is with the difference between the DMP parameters output by the neural network and the parameters of the DMP that represents the training trajectory from the database. However, this is not a proper measure (metrics) for the difference between actual trajectories. It is better to use metrics that directly measure the Euclidean distance between the points of output trajectory (generated by the DMP computed by the neural network) and the training writing trajectory. Here the problem arises that it is more difficult to compute the gradients of such error function because we need to differentiate the metrics with respect to the output parameters of the network, i.e. DMP parameters. We derived differential equations that can be used to compute these gradients, which are then used to train the weights of the deep encoder-decoder network. The resulting system was tested on a humanoid robot Talos. The experiment starts by showing to the robot a human-written digit on a sheet of paper. Using standard computer vision algorithms, the robot

finds the sheet in its camera image and uses the result as input to the deep encoder-decoder network. The network then generates the handwriting trajectory that can be executed by the robot to write the copy of the digit seen on the paper.

Designing an upper body exoskeleton

Miha Dežman[1,2], Tamim Asfour[3], Aleš Ude[1], Andrej Gams[1]

[1]Department of Automation, Biocybernetics and Robotics, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[3]Institute for Anthropomatics and Robotics, Karlsruhe Institute of Technology, Karlsruhe, Germany

Wearable devices or exoskeletons will be an important tool for users with various disabilities, or users in the need of effort reduction while they perform various tasks and works. Overall, the exoskeleton device is a complex device that encompasses various components. They need to interact harmoniously or otherwise instead of assistance, the opposite results are achieved. While it sounds easy at first, the design of such a device is a challenging task and can be split into the problems of:

- **actuation**, where novel actuator architectures beyond classical geared motor are required with properties on par with human muscles. Only then can an exoskeleton remain light and when attached to the human user, successfully follow human performance and assist him.
- **exoskeleton interface**, which needs to be sturdy enough to transmit large torque/forces from the actuators onto the user. Yet, on the other hand, light and kinematically suitable, so it does not obstruct the user and impede on him any undesired force and torques. Since the users' body postures are diverse, the exo-interface must allow the possibility of manual adaptation of its size, which introduces further mechanical complexity.

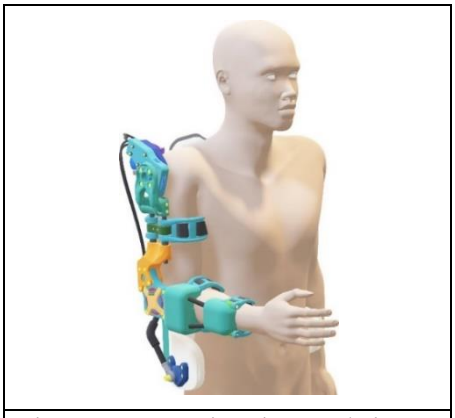

Fig. 1: User wearing the exoskeleton.

- **electronics and the controller** that need to be chosen appropriately, including the position sensors, force/torque sensors, motor drives, the motors themselves, the controller, and batteries. The electronic components heat up during the use, so a way to cool down the units also needs to be considered. All electronic components need to be connected with each other through a suitable communication bus and a protocol, which needs to provide sufficient communication speed and control frequency.
- **software and algorithms**, which is perhaps the most difficult aspect due to the unknown human factor. Advanced control and machine learning techniques need to be used where the controller predicts the user's intention and adapts not only the current state of the user, but also considers the user's adaptation to the device over longer periods of time.

Some of above problems were targeted during our design. The prototype upper-body exoskeleton (Fig. 1 and 2) is primarily intended to empower its user by increasing his strength. Both institutes will use the prototype for design and research of novel control algorithms, and attempt to provide a solution for the last problem on the above list.

Figure 2: Back side of the exoskeleton.

Gaussian Process Regression for Big Data

Tadej Krivec[1,2], Juš Kocijan[1]

[1]Department of Systems and Control, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

The ever-growing amount of data in the industry increased the popularity of data-driven identification. Gaussian Process (GP) is a popular machine learning method for solving such regression problems. It is a Bayesian method which provides a confidence estimation of the predicted values. The method suffers from the cubic complexity (calculation of covariance matrix inverse) with the increasing amount of data. Overview of the different approximations for the full GP regression will be presented. One of the concepts is a global approximation where we are looking for a random subset of training data or try to find either a sparse or a low-rank representation of the covariance matrix. Second deals with a local representation where training is done on local subsets. In order to guarantee smooth predictions a combination of local models is used (mixture-of-experts, product-of-experts). Open issues are presented at the end.

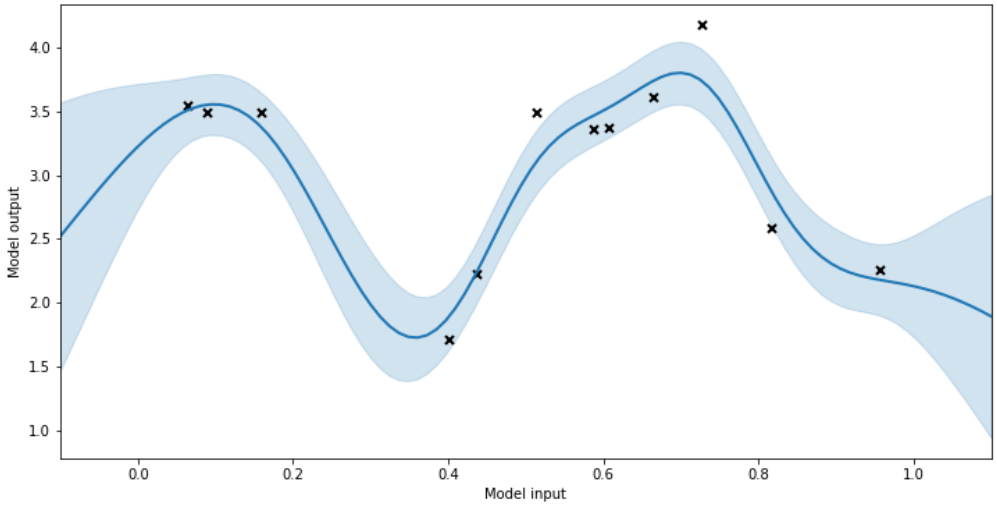

Figure 1: An example of GP regression

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Human intuitive reward systems for reinforcement learning of robotic actions in latent space of deep autoencoder network

Zvezdan Lončarević [1,2], Rok Pahič [1,2], Mihael Simonič [1], Andrej Gams [1,2]

[1]Department of Automation, Biocybernetics and Robotics, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

In the near future, robots are expected to become mass-consumer product that will operate in unstructured environments and share their workspace with humans while relying only on noisy sensory data. That is why standard ways of programming them for each variation of the task is impossible. In contemporary robotics, two most common ways of dealing with this problem are reinforcement learning (RL) and learning by imitation. Incorporating these two approaches so that the action is learned by imitation and then refined by RL would increase autonomy of nowadays high degree-of-freedom robots.

While it is usual that robotic trajectories are represented using the parametric representations such as Dynamic Movement Primitives (DMPs), Probabilistic Movement Primitives (PMPs), Hidden Markov Models (HMMs) and others, they still leave too big search space for reinforcement learning. That is why we decided to encode the recorded DMP trajectories using neural networks so that in the latent space only important features are extracted and learned using RL until the robot action is successfully performed. Moreover, to avoid the need for expensive sensors that can be practically calibrated only in laboratory conditions, we introduced reward systems that are intuitive for humans so that robot learning is based only on the feedback provided by the human teacher. This is possible only with the learning algorithms that are based on terminal reward, such as PoWER and PI^2. We have chosen PoWER (Policy Learning by Weighting Exploration with the Returns) for our approach because of its robustness with the respect to reward functions that are inserted into sampling matrix to exploit previous experience.

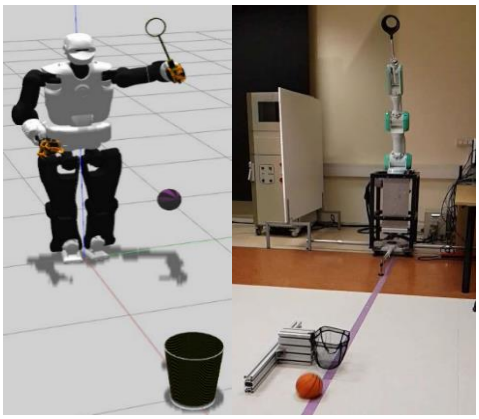

Fig. 1: Talos (left) and Mitsubishi (right) throwing

Our approach was tested on the example of throwing action on two robots: Mitsubishi PA10 (Fig. 1-right) where the initial DMP trajectory was recorded in joint space and then encoded in a neural network, and also on the humanoid robot Talos from PAL robotics, where we tested learning with encoding the trajectories into the neural network from both joint space DMPs and Cartesian space DMPs (CDMPS). Experiments with Talos were done using only simulation (Fig 1-left) because of faster generation of the database that was needed for neural network training. Robot successfully learned the throwing action with both reward systems we introduced: unsigned five-star reward system where human teacher was giving a reward on a scale of 1-5, and signed reward system where the human teacher could choose a reward from the set: {too short, short, hit, long, too long}. It turned out that there is no statistically significant difference between introduced human intuitive reward systems and a complex reward system based on the real measurement and that the learning in latent space outperformed learning in DMP/CDMP space, no matter the reward complexity.

INSENSION: Giving a voice to those who don't have one

Matej Cigale[1,2], Gašper Slapničar[1], Mitja Luštrek[1,2]

[1] Department of Intelligent Systems, Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana
[2] Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana

People with profound intellectual and multiple disabilities (PIMD) are an extremely heterogeneous group facing great challenges in their daily lives. Severe cognitive, motor and sensory disabilities makes this population reliant on outside care for most daily tasks, and thus extremely vulnerable. While these individuals are exactly the ones that would benefit the most from intelligent systems in their vicinity, they are unable to use them due to relative high complexity of these systems. The main problem is their complete lack of producing or understanding of symbolic communication.

The goal of our work is to provide an intelligent framework that enables them to communicate their wishes and feelings to the outside world. Through this system they can also influence some applications that would empower them with the ability to play their favorite music, control the lights in their room, and even offer some basic communication opportunities to them so that they can influence and communicate with the people around them.

The first step is to recognize Non-Verbal Signals (NVS) (e.g., certain gestures, facial expressions) expressed by the people with PIMD and important features of their environment (e.g., presence of a caregiver, temperature, objects they have access to). In other words, the latter is the context where this communication takes place. Using the NVS, the system can infer the behavioral state of the person with PIMD, (e.g. pleasure or displeasure), and what is she trying to communicate.

Interpretation of NVS of people with PIMD is a challenging task, since each individual is unique with different abilities and specific signals. Because of this, no general-purpose system can be developed and personalized classification methods must be used. Collecting a large set of data for each individual is neither practical nor feasible. Mappings between certain NVS and behavioral states are known to those close to the person, and this expert knowledge should be used in the decision making process. We developed machine-learning algorithms that are designed to work with a limited amount of data and can incorporate expert knowledge that is provided by caregivers.

In addition, we will be extracting the behavioral state from the Photoplethysmogram (PPG). This signal can be obtained from a wearable device or from specialized software that can extract the PPG signal from the visible skin on the face. It describes the changes of blood volume in the skin tissue and is periodic as it reflects the beating of the heart. We have currently implemented two state-of-the-art algorithms for PPG extraction from videos, namely chrominance-based algorithm (CHROM) and plane-orthogonal-to-skin algorithm (POS), which allow us to estimate heart rate (HR) and heart-rate variability (HRV) from the reconstructed PPG. These are to be updated with a deep learning algorithm which will attempt to additionally improve the reconstructed waveforms for more precise HR estimation.

Method for Fast Estimation of the Parameters In Order to Detect Different Operating Conditions of Electrochemical Hydrogen Compressors

Gjorgji Nusev[1,2], Gregor Dolanc[1], Pavle Boškoski[1]

[1]Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
[2] Jožef Stefan International Postgraduate School, Jamova cesta 39, SI-1000 Ljubljana, Slovenia

Renewable energy sources such as wind turbine farms and solar power plants are ubiquitous in our energy systems. Despite their indisputable positive environmental impact, their main drawback is the intermittent power output. In many cases, the generated energy has a significant mismatch to the current demand on the grid. Thus, there is an apparent need for energy storage installations, that are capable of storing vast amounts of energy in times of surplus whilst being capable for instant on-demand delivery. Currently there are two competing tracks addressing these issues: batteries and fuel cells. Our focus is on the second one.

Fuel cells operate on the chemical energy stored in form of hydrogen molecules. Hydrogen is one of the most abundant elements and has great properties of being an energy-rich gas and highly versatile. This makes hydrogen as one of the most suitable candidate to be used as an efficient energy storage media [1,2]. In the hydrogen production and storage chain the biggest power consumption is the compression step. There are two general categories of hydrogen compressors: mechanical, which uses adiabatic process and non-mechanical, which mainly uses isothermal process for compression. Electrochemical hydrogen pump (EHP) uses electricity to extract hydrogen from miscellaneous gas mixtures and compress it to very high pressures (~500 bars). Also the absence of moving parts makes them more efficient when comparing with the conventional mechanical compressors [3]. EHP operation is very similar to that of a PEM Fuel Cells and their performances are heavily dependent on the humidity of the membrane. Since direct monitoring of membrane humidity is practically impossible, the goal is to devise a method for online humidity estimation. The proposed method operates by estimating the parameters of a previously selected equivalent circuit model (ECM) using directly measurable data through identification of fractional order systems [4]. When compared the proposed method to the classical electrochemical impedance spectroscopy, the whole characterisation process is completed in a significantly shorter amount of time (in order of several seconds). The method was evaluated on an industrial grad hydrogen compression unit capable of achieving 1000 bars of pressure.

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Parameter Control in Evolutionary Bilevel Optimisation

Margarita Antoniou[1,2], Peter Korosec[1,2], Gregor Papa[1,2]

[1]Computer Systems Department, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

Evolutionary algorithms (EAs) are a nature-inspired population based search method for solving difficult optimisation problems. They apply principles of natural evolution that allow populations of species to adapt to their environment, such as the genetic inheritance and the survival of the fittest. In general, the process of EAs is based on the concepts of exploration and exploitation of the search space through selection and reproduction (mutation and crossover) operators. The efficiency of an EA depends heavily on the selection of suitable values of these operators. One can set these parameter values in advance, before the optimisation (parameter tuning) or can change them during the run (parameter control), by getting some kind of feedback from the evolution process itself [1, 2].

Bilevel problem is a class of problems, where one optimisation problem (upper level/ leader) has another optimisation problem (lower level/ follower) as a constraint, following a hierarchy of decisions. Applications of such problems can be found in a variety of domains such as transportation, economics, engineering, reliability based design optimisation and optimal control. The optimisation of a bilevel problem aims to achieve the optimum solution of the upper level, taking into consideration the optimal lower level values too**.** This procedure becomes rather challenging, as the landscape of the lower level is changing for each upper level candidate solution. Parameter control when using EAs to tackle with this problem, can be useful. In our approach, we aim to investigate the effect of parameter control in a nested bilevel evolutionary algorithm. The evolutionary algorithm that is used in both levels is the Differential Evolution algorithm [3], a simple yet powerful EA for global optimisation. The parameters that we adapt are the mutation (F), the crossover probability (CR), and the selection ranking schema, while the performance of the algorithm is evaluated by solving test-problems taken from literature [4].

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Acknowledgement: This work is funded by the European Commission's H2020 program, through the UTOPIAE Marie Curie Innovative Training Network, H2020-MSCA-ITN-2016, Grant agreement number 722734.

Routing in wireless network considering meteorological effects

Tadeja Saje[1], Gorazd Kandus[2], Matjaž Vidmar[3]

[1]Mednarodna podiplomska šola Jožefa Stefana, ICT

[2]IJS, Mednarodna podiplomska šola Jožefa Stefana

[3]Faculty of Electrical Engineering University of Ljubljana

Wireless networks are supposed to operate in different weather conditions. Communication might be distributed due to rain attenuation, changing multipath and/or degraded antenna performances. Rain attenuation below 30 GHz is mainly due to dielectric losses of water. Rain attenuation above 30 GHz is mainly due to Rayleigh scattering on rain drops. A temperature inversion and/or wet soil and vegetation may change the multipath. Rain drops and even more important, ice on the surface of antennas degrade the gain of the latter and increase unwanted side lobes. The rain attenuation can be predicted from the weather-radar image. It is more difficult to estimate the effect of a temperature inversion and/or wet soil and vegetation. The degradation of the antenna performances can be estimated from impedance changes.

The routing protocols used in reliable and stable wired networks are unsuitable for continuously and sometimes fast changing radio networks. In these conditions it makes sense to use user-source routing. The latter is possible in the existing NBP (Non-Flawless Protocol) network, where each user acts as a network node and is allowed to test an arbitrary radio link between two arbitrary network nodes.

In our work we propose to measure the radio links and equipment in the existing NBP network using different methods: measuring signal strengths, measuring antenna impedances, considering the current weather situation and weather-radar data. Preliminary calculations estimate that at frequencies above 10 GHz using SDR (Software-Defined Radio) and smart-antenna techniques the same communication radios can be used as small weather radars at the same time, measuring rain attenuation along the affected radio paths as well as unwanted multipath and degraded antenna performances. From the many available sources of propagation data we will try to learn using artificial-intelligence techniques which routing is optimal in the current network status. The practical application of the results of our research is the 5G rural access network proposed to operate in the 26-30 GHz frequency band both for network-feeder links as well as user links.

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Visualization of multilayer networks by node embedding

Blaž Škrlj[1], Jan Kralj[2], Nada Lavrač[2]

[1]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[2]Jožef Stefan Institute, Ljubljana, Slovenia

Visualization and analysis of large, multi-modal real-world networks is an open problem. We propose a novel approach to visualization of multi-layered networks; networks which consist of multiple different node types and edges. The approach is a significant extension of the [2], where we attempted to visualize larger networks using only the Barnes-Hut approximation of the force-directed layout. As the recent trends in machine learning attempt to project heterogeneous data sources to the same vector space, where down-stream analytics and processing can be executed, we attempted to transfer some of these ideas to the field of graph visualization.

The proposed approach operates by first embedding a given network into a d-dimensional vector space [1]. Next, the d-dimensional representation is projected to two dimensions, where it serves as the initialization of the Barnes-Hut force-directed layout algorithm. The proposed approach scales to large networks, as the initial, computationally expensive embedding phase is being computed on general-purpose GPUs, decreasing the computation times significantly.

We belive the proposed approach could be of use of large metagenomic gene-gene interaction networks, where the number of edges can exceed 1B. Furthermore, the proposed approach was already used to visualize the human interactome on an of-the-shelf laptop.

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Web API for DEX Decision Modeling

Adem Kikaj[1,2], Marko Bohanec[2]

[1]Department of Knowledge Technologies, Jožef Stefan Institute, Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

DEX (Decision EXpert) is a decision modeling methodology used in decision-support applications in various areas such as the economy, finance, agriculture, and tourism. Currently, the DEX method is implemented in a freely available software called DEXi, which runs on Windows platforms. This decision-making software is useful for supporting complex decision-making tasks. DEXi supports: (1) development of qualitative multi-attribute models and (2) application of these models for the evaluation and analysis of decision options. The DEX methodology is also distributed partly in other software-based platforms [1].

For easing the decision-making process DEX methodology is continually in process of development of the new features [2]. With all new extensions, all the existing platforms that implement DEX need to be updated and upgraded. The current implementation DEXi is just desktop-based software and is getting outdated as new advanced methods are being developed. There is a need for a new implementation following the recent trends in software development, providing a centralized and robust web-based implementation of DEX for end-users. The end-users include decision makers that wish to develop their own decision models, and those who wish to use the DEX methodology in their software products, such as decision support systems.

DEX as a web-based solution should fulfil the main needs as retrieving, analyzing, displaying, and providing access to multimedia documents and data, as well as easing the communication within a distributed decision-making team. Web-based applications are a robust modern solution regarding security, performance, portability, and scalability. However, we propose that the DEX methodology not to be implemented directly as a web-based application, but to develop a Web API, thus, going further with the functions that are provided from such implementations.

In software development, an application programming interface (API) is a set of subroutine definitions, communication protocols, and tools for building software. Web APIs define a communication interface between the enterprise and application, which is done through the HTTP/HTTPS protocol. There are mainly two types of Web APIs: SOAP (Simple Object Access Protocol) and REST (Representational State Transfer). The new implementation of DEX methodology is going to be implemented using the REST Architecture since it permits many data formats (plain text, HTML, XML, and JSON), it is lightweight and supports SSL (Secure Sockets Layer) and HTTPS. Internally, the DEX method will be implemented as a Java-based library, the API is going to be developed using the well-established Java framework for RESTful API, called Dropwizard [3].

The design of an API for the DEX methodology will have a significant impact because of the principle of modular programming. It will provide a common platform allowing multiple applications built in various technologies to use or communicate with commonly available DEX-methodology services.

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Nanoznanosti in nanotehnologije (Nanosciences and Nanotechnologies)

ALD Al_2O_3 coatings as protection against corrosion of biomedical materials stainless steel and titanium

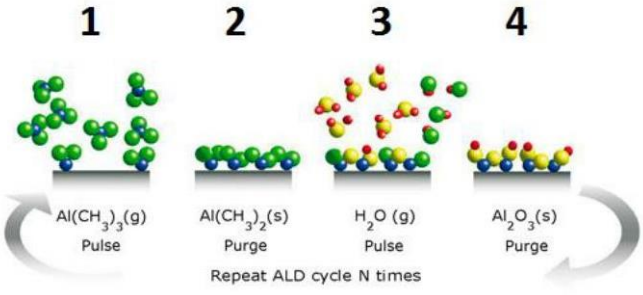
Ivan Spajić[1,2], Ingrid Milošev[1]

[1]Jožef Stefan Institute, Department of Physical and Organic Chemistry, Jamova cesta 39, 1000 Ljubljana

[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana

Biomedical materials stainless steel (SS316L) and commercially pure titanium grade II (CP-Ti) were coated with thin alumina (Al_2O_3) coatings using Atomic Layer Deposition (ALD) technique. The aim of deposition process was to improve the corrosion resistance of these materials that have been used for a long time in biomedicine as parts of biomedical devices or implants [1, 2].

ALD deposition was performed using a trimethylaluminium as a precursor to obtain a 100 nm thick Al_2O_3 layer (Fig. 1). Prior deposition process and electrochemical tests, all samples were subjected to metallographic preparation, rinsed and ultrasonicated. Electrochemical measurements of bare and Al_2O_3-coated SS316L and CP-Ti samples were carried out in 0.1 M NaCl as electrolyte. According to potentiodynamic (PD) measurements bare CP-Ti attained much broader passive range in chloride solution than bare SS316L which is subjected to localized breakdown of the passive film. Further, CP-Ti exhibits lower corrosion current density than SS316L; therefore, overall resistance of CP-Ti is much better than that of SS316L. However, electrochemical impedance spectroscopy (EIS) measurements show that these two metals have similar corrosion properties after 10 days immersion in the corrosive electrolyte. The corrosion protection of SS316L and CP-Ti coated by ALD Al_2O_3 coatings proved to be very effective resulting in reducing the current density in the passive region from ca. 10^{-7} to 10^{-11} A/cm^2 for SS316L, and from ca. 10^{-6} to 10^{-11} A/cm^2 for CP-Ti, the same is reported here [3]. According to EIS measurements, these coatings retain their barrier properties relatively well after 5 days immersion in the corrosive electrolyte. The thickness of deposited coatings was measured by optical ellipsometry and profilometer. Qualitative chemical composition of deposited Al_2O_3 was analysed using Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) technique.



$$2 * Al(CH_3)_3 + 3 * H_2O \rightarrow Al_2O_3 + 6 * CH_4$$

Figure 1. Schematic presentation of ALD process for deposition of Al_2O_3 coating in four steps.

Acknowledgment: This project has received funding from the European Union's Horizon H2020 research and innovation programme under the Marie Skłodowska Curie grant agreement No. 764977

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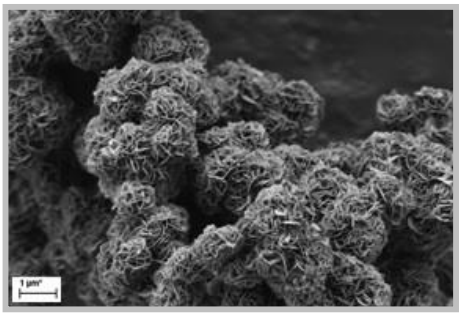
Can nanoparticles be tamed?

Hermina Hudelja[1,2], Andraž Kocjan[1,2]

[1]Department for Nanostructured Materials, Jožef Stefan Institute, 1000 Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, 1000 Ljubljana, Slovenia

Nanoparticles belong to the family of nanomaterials, where at least one dimension falls below 100 nm. They possess a very high surface-to-volume ratio, which is the reason for different and usually beneficial properties in comparison to coarser counterparts. Implementation of nanoparticles made a major contribution to development of various fields such as catalysis, insulation, pharmaceutical products, decontamination of water (adsorption/separation), reduction of greenhouse gases, smart fabrics, cancer treatment, etc.[1,2]. However, beside their broad usefulness, not only their processing is difficult, but also their extensive production may pose health and environmental hazards,[1] which, thus, must be taken into consideration.



We have tackled these problems and tamed the nanoparticles by taking advantage of *in-situ* assembly of synthesized nanoparticles into ordered, micron-sized hierarchical structures with preserved nanoscale features. These hierarchically structured coarser entities of nanoparticles were then stabilised in water to form predictable aqueous suspensions. Freeze-casting shaping technique followed by freeze drying was exploited to form ultralight, highly porous but still sufficiently strong green bodies (not requiring post calcination steps) with improved surface properties that have opened number of possible applications, varying from catalysis, adsorption/separation to thermal insulation.

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Comparison of two high-throughput sequencing technologies: MinION (Oxford Nanopore Technologies) and MiSeq (Illumina platform) for detection of plant viruses and viroids

Anja Pecman[1,2], Denis Kutnjak[1], Ian Adams[3], Ion Gutiérrez-Aguirre[1], Adrian Fox[3], Neil Boonham[4] and Maja Ravnikar[1,5]

[1]Department of Biotechnology and Systems Biology, National Institute of Biology, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[3]Fera Science Ltd., York, United Kingdom
[4]Institute for Agri-Food Research and Innovation, Newcastle University, Newcastle upon Tyne, United Kingdom
[5]Wine Research Centre, University of Nova Gorica, Nova Gorica, Slovenia

Plant viruses and viroids are among the most challenging of plant pathogens to detect, which is in part, due to the lack of conserved genes across taxa such that DNA metabarcoding, which is typically applied to bacteria and fungi cannot be used. The only non-targeted molecular method developed to-date for plant virus/ viroid detection is high throughput sequencing (HTS). First introduced for plant virus detection in 2009, HTS has now become a common tool for plant virus/viroid detection and discovery in diagnostic laboratories worldwide. In parallel, especially due to globalisation, the trade of plants, plant products and consequently the number of samples to be tested for the presence of plant viruses/viroids by plant protection inspection services in the field or at outbreak sites, steadily increased. Hence, any development of HTS methods that facilitate the adoption in routine testing laboratories, extension laboratories and sampling sites would be extremely practical. With this in mind, we compared an established HTS approach based on the MiSeq benchtop sequencer (Illumina) with direct RNA sequencing using the MinION (Oxford Nanopore Technologies). For the comparison, we selected a broad range of samples, containing plant viroids and viruses, which differ in their genome organisation and concentration in tested samples. The samples contained plant viruses/viroids in single or mixed infections. The aim of this study was to evaluate both sequencing approaches in term of their robustness, sensitivity, resolution and the range of detection, using different bioinformatics tools and pipelines. The results will significantly improve the understanding of the MinION performance for plant protection applications. Nevertheless, the advantages and potential barriers for the use of novel on-site technologies for diagnostics of plant pathogens will be addressed.

Corrosion protection of magnetic materials

Nikolina Lešić[1,2], Ingrid Milošev[1]

[1]Jožef Stefan Institute, Department of Physical and Organic Chemistry, Jamova cesta 39, 1000 Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

The permanent magnets based on intermetallic compounds of rare earth elements, such as Nd-Fe-B [1] and Sm-Fe-N [2] magnets, found numerous applications thanks to their excellent magnetic properties. Therefore, these magnets are essential components in many electric devices. However, their corrosion resistance is very poor in various environments [3–5]. Magnetic materials used in automobile and other industries are subjected to harsh environments including aggressive aqueous and non-aqueous media and changing temperature and pressure. The corrosion causes surface degradation and thereby the functional performance of these materials is endangered. To avoid that, additional protection is required to protect the basic magnetic substrates. The most effective method is preparation of protective coatings on their surfaces. In order to develop corrosion protection, it is important to understand the corrosion behaviour of magnetic Nd-Fe-B and Sm-Fe-N materials. To do so, we will start our investigation from individual metal components to more complex systems in actual magnetic materials. That will allow us to study the effect of each metal component in the corrosion process and to identify the factors affecting the overall corrosion mechanism of magnetic materials. First, corrosion resistance of the pure metals: Fe, Nd and Sm will be investigated followed by the study of Nd-Fe and Sm-Fe alloys. Finally, complex systems Nd-Fe-B and Sm-Fe-N magnetic materials will be investigated. Corrosion resistance of these materials will be investigated in different environments (different pH, concentration, temperature and some other conditions). Crystal structure, morphology and chemical composition of the materials before and after corrosion tests will be investigated using different surface analytical methods (XRD, XPS, SEM/EDS, etc.). Electrochemical and corrosion properties of materials will be investigated using electrochemical techniques (electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization curves) and standard industrial testing (salt spray chamber and immersion test).
After investigation of corrosion process on individual metal components (Nd, Sm, Fe), their alloys (Nd-Fe and Sm-Fe) and composite magnetic materials (Nd-Fe-B and Sm-Fe-N), corrosion protection of these materials will be developed. In order to find corrosion protection for these materials, two procedures will be explored: wet chemical (sol-gel) and gas chemical (e.g. atomic layer deposition). Sol-gel procedure includes development of hybrid coatings based on metal alkoxides and organic compounds, and atomic layer deposition (ALD) includes inorganic coatings based on aluminium, zirconium or other oxides. The properties of the coatings will be characterized as a function of deposition parameters. As above, electrochemical techniques, standardized corrosion testing and surface analytical methods will be used to investigate the efficiency of corrosion protection of developed coatings and the change in chemical composition and surface morphology upon corrosion testing.

Acknowledgment: This project has received funding from the European Union's Horizon H2020 research and innovation programme under the Marie Skłodowska Curie grant agreement No. 766007.

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Deep Cryogenic Treatment of Metallic Materials

Patricia Jovičević Klug[1,2], Bojan Podgornik[1]

[1]Institute of Metals and Technology, Department of Metallic Materials and Technology, Lepi pot 11, 1000 Ljubljana
[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

Deep cryogenic treatment (DCT) is a type of cryogenic treatment, where a metallic material is subjected to temperatures below -150°C, normally to temperatures of liquid nitrogen (-196 °C) [1]–[5]. When material is altered with DCT as a part of heat treatment, changes in microstructure are induced due to formation of new grains, change in grain size, change of solubility of atoms, movement of dislocations, alteration of crystal structure, and finally the new phase formation. Changes in the metallic material can have positive or negative effects on the final properties. The metallic material's performance and later performance of manufactured components and tools from this specific material are depended on the selection of proper design, proper material, accuracy with which the tool is made and application of proper heat treatment, including any eventual DCT [3]–[5]. Metallic materials are ferrous and non-ferrous metals. Ferrous metals (different grades of steel) and non-ferrous alloys (aluminum, magnesium, titanium, nickel etc.) have been in last years increasingly treated by DCT to alter their properties [5]. DCT treatment has shown to reduce density of defects in crystal structure, increase wear resistance of material, increase hardness, improve toughness, and reduce tensile strength and corrosion resistance [6-10]. However, some researchers also reported results showing no change in properties (toughness, hardness, corrosion resistance, etc.) or even deterioration when subjected to DCT treatment [6]–[8]. This leads to a lack of consistency and reliability of the treatment process, which is needed for successful application in industry. Nevertheless, to prove with certainty the resulting outcome of DCT on the material properties and understanding the reason for the variation in metallic materials properties when subjected to DCT, a more systematic approach and testing with different variables should be conducted in the future.

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Development of the Dual-beam ion irradiation facility for FUsion materials

Marin Vukšić[1, 2], Tonči Tadić[1], Stjepko Fazinić[1], Milko Jakšić[1], Andro Kovačić[1], Željko Periša[1], Zdravko Siketić[1], Natko Skukan[1], Damir Španja[1], Milan Vićentijević[1], Donny Domagoj Cosic[1], Zvonko Kolar[1], Matija Capor[3], Roko Gracin[3], Wataru Kada[4], Chris Hardie[5]

[1]Ruđer Bošković Institute, Bijenička 54, 10000 Zagreb, Croatia

[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

[3]Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Ivana Lučića 5, 10000 Zagreb, Croatia

[4]Department of Electric Engineering, Gunma University, 42 Aramakimachi, 371-8510 Maebashi, Gunma Prefecture, Japan

[5]UKAEA, Culham Centre for Fusion Energy, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, UK

The Dual-beam ion irradiation facility for FUsion materials (DiFU) is under development at the Ruđer Bošković Institute in Zagreb, Croatia, allowing irradiation of fusion-relevant samples by one or two ion beams. The two beam lines meet at the centre of the DiFU chamber at an angle of 17°. The ion beams are accelerated by a 6 MV HVEC Tandem Van de Graaff accelerator and a 1 MV HVE Tandetron accelerator. When conducted with self-ions, ion beam irradiation simulates fast-neutron-induced damage of samples and simultaneous hydrogen or helium implantation mirrors fast-neutron-induced hydrogen or helium bubble formation. To ensure that the sample is irradiated homogenously throughout its depth (up to the maximum range of ions), a set of degrader foils is placed at the entrance to the chamber.

Ion beam scanning systems enable fast electrostatic sweeping of the beams over the samples at frequencies 256-3200 Hz in the horizontal and vertical axes, enabling homogeneous irradiation of areas from 5x5 to 30x30 mm^2.

The sample holder enables XYZ positioning of heated, cooled or room temperature samples. Ion fluxes are measured indirectly by insertion of two large Faraday cups in front of the sample holder. The ion flux is also monitored continuously, by two sets of XY slits, which define the size of the irradiated area of the sample. Sample temperature is monitored by a set of thermocouples, an IR camera and a high-sensitive video-camera.

Acknowledgement: This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training program 2019–2020 under Grant Agreement No. 633053.

Discovery of candidate genes for irregular monoterpene synthesis in *Planococcus citri*, using transcriptome analysis

Mojca Juteršek[1,2], Marko Petek[1], Špela Baebler[1], Kristina Gruden[1]

[1]*National Institute of Biology, Department of Biotechnology and Systems Biology, Večna pot 111, SI-1000 Ljubljana, Slovenia*

[2]*Jožef Stefan International Postgraduate School, Jamova cesta 39, SI-1000 Ljubljana, Slovenia*

Mealybugs and scales (superfamily Coccoidea) are herbivorous, sap-sucking insect pests, inflicting direct or indirect damage on agricultural plants. Their sexual reproduction depends on male-attracting species-specific pheromones produced and emitted by females. Coccoidea pheromones usually consist of irregular terpenoids, some of which possess unique skeletons, making them difficult to identify and synthesize [1].

Besides being studied from the chemical point of view, insect pheromones are also considered as potential environmentally friendly alternatives to traditional pesticides with unspecific toxic mode of action. Sprayed in the air, they mask natural female-produced pheromones and disrupt mating, or are dispensed in the form of pheromone traps, luring flying males away from crop fields infested with wingless females. Pheromone traps have also proved to be highly useful for detecting and monitoring pest infestations, facilitating earlier response and thus rationalizing and decreasing the use of conventional pesticides. Synthetic pheromones are already being produced and used in crop fields, but chemical synthesis can be laborious, expensive and can result in hazardous waste or byproducts. To improve sustainability of pheromones' use, biotechnological production in transgenic plants has been suggested and successfully implemented [2]. For this purpose it is crucial to determine biosynthetic steps in pheromone synthesis and identify the involved genes. We have focused on citrus mealybug, *Planococcus citri*, a common pest on subtropical fruits and ornamentals, that uses a cyclobutane-containing pheromone (+)-(1R)-cis-2,2-dimethyl-3-isopropenylcyclobutanemethanol acetate. Its structure is a result of irregular non-head-to-tail 1-4' coupling, catalysed by a yet unknown enzyme. To determine genes of pheromone biosynthetic pathway in *P. citri*, we compared transcriptomes of virgin females (expected to actively synthesize the pheromone) and mated females and identified differentially expressed terpene synthases with homology to other insect or plant enzymes catalysing synthesis of irregular terpenoids. Additionally, we also performed *de novo* transcriptome assembly to obtain correct cDNA sequences, which will be used for protein expression and enzymatic assays to confirm their biosynthetic activity. Upon confirmation of their role in synthesis of the *P. citri* pheromone, most promising genes could be transferred to plants or used *in vitro* for semi-synthetic production of cyclobutane-containing Coccoidea pheromones.

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Acknowledgement: This work was done as a part of ERA CoBioTech project SUSPHIRE in collaboration with partners from Spain and Germany.

Effect of alkyl chain with methyl-, ethyl- and butyl- methacrylate on corrosion and hydrophobic properties of hybrid sol-gel

Damir Hamulić[1,2], Ingrid Milošev[1]

[1] *Jožef Stefan Institute, Department of Physical and Organic Chemistry, Jamova c. 39, 1000 Ljubljana, Slovenia*
[2] *Jožef Stefan International Postgraduate School, Jamova c. 39, 1000 Ljubljana, Slovenia*

Corrosion of metals is one of the important problems in industry due to material degradation and large economic impact on a global scale. There are many ways how to protect the metals against harsh environment including thick paints, cathodic and anodic protection, and corrosion inhibitors which form a protective film, etc. In recent years, research in the field of green and ecologically acceptable paints for maritime environment has intensified due to new regulations that prohibit the use of toxic biocides and metals such as copper or silver [1]. To avoid the penetration of water or corrosive species such as chloride anions to reach the metal surface, the coating itself has to have good barrier properties. Therefore, coating surface is the first line in the battle against corrosion. It is desirable that the surface would be hydrophobic to repel water drops and prevent electrolytic solution to reach the substrate and cause its dissolution. To increase hydrophobicity, the surface energy need to be reduced which can be achieved by changing the surface chemical composition; for example by organic molecules. Chemical groups such as $–CH_3$ are most common in the industry of organic coatings. We propose to use additional $–CH_2–$ groups in order to increase the length of alkyl chain and, consequently, reduce the surface energy.

In our study the effect of different length of alkyl chain (methyl-, ethyl- and butyl methacrylate) on the hydrophobic and corrosion properties of hybrid sol-gel coating based on MAPTMS (3-(trimethoxysilyl)propyl methacrylate) and TEOS (tetraethyl orthosilicate) was investigated. Coatings, denoted as siloxane-PMMA, –PEMA and –PBMA, were deposited on aluminium substrate AA7075-T6. Longer alkyl chains increase hydrophobicity (expressed as water contact angle) from 70° for siloxane-PMMA to 79° for siloxane-PBMA. The increase in chain length improves the corrosion properties as well, as measured using electrochemical impedance spectroscopy in 0.1 M NaCl. The development of coatings with longer alkyl chains may be potentially advantageous for application in green-paints industry aimed for corrosion protection and biofouling.

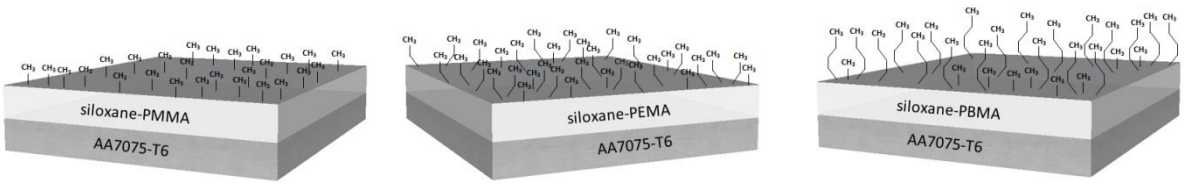

Fig. 1. A graphic presentation of siloxane coatings with different chemical groups (methyl, ethyl, butyl).

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Electrostatic interaction between magnetic nanoplatelets in alcohols

Patricija Hribar Boštjančič[1, 2], Matija Tomšič[3], Andrej Jamnik[3], Darja Lisjak[4], Alenka Mertelj[1]

[1]Department of Complex Matter, Jožef Stefan Institute, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[3]Faculty of Chemistry and Chemical Technology, Ljubljana, Slovenia
[4] Department for Materials Synthesis, Jožef Stefan Institute, Ljubljana, Slovenia

A room–temperature liquid magnet was discovered in concentrated suspensions of magnetic nanoplatelets in 1-butanol, in which magnetic nanoplatelets spontaneously order and form a ferromagnetic nematic phase [1]. Barium hexaferrite (BHF) nanoplatelets with magnetic moments perpendicular to their basal plane are the most important ingredient of these suspensions. Magnetic domains are formed in the concentrated suspension as a consequence of the magnetic alignment of the nanoplatelets in large macroscopic regions [1]. The electrostatic interactions between the nanoplatelets play a crucial role in the suspension stability and in the formation of ferromagnetic nematic suspension. Sufficient electrosteric repulsion is ensured by a surface double layer of dodecylbenzenesulfonic acid (DBSA) [2]. The aim of this work was to evaluate and understand the role of electrostatic interactions in the ferromagnetic nematic suspensions. Therefore, we investigated suspensions of the hydrothermally synthesized and DBSA–functionalized BHF nanoplatelets in tert-butanol, 1-hexanol, 1-butanol and 2-propanol. In particular, we focused on parameters that determine electrostatic interaction and Debye screening length, such as dielectric constant, surface charge and concentration of free ions. We performed small-angle X-ray scattering (SAXS), conductivity and electrophoretic-mobility measurements.

SAXS measurements confirmed the colloidal stability of the nanoplatelets in all alcohols that were used as solvents. As determined from the conductivity values, in average, 3 DBSA molecules/nm^2 cover the nanoplatelet's surface in 30 g L^{-1} suspensions, while the fraction of free DBSA is between 6 and 7 %. The latter increases with dilution of the suspension. Subsequent additions of the DBSA to the suspensions do not noticeably change electrophoretic mobility, meaning that higher DBSA concentrations do not affect the suspension stability. The surface charge of the nanoplatelets rises with the increasing dielectric constant of the alcohol. Consequently, the strength of the electrostatic repulsion between them also increases. The higher surface charge corresponds to an increase of the DBSA dissociation degree in more polar alcohols. The increasing dielectric constant also causes the decrease of the Debye screening length that determines the range of the electrostatic interaction. For the formation of ferromagnetic nematic phase, it is crucial to balance the magnetic dipolar attraction and electrostatic repulsion between the nanoplatelets. We showed that this can be achieved by optimizing the DBSA concentration and solvent's dielectric constant.

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Fabricating graphene-based nanodevices for new generation standards of electrical conductance

Aswathy Vasudevan[1,2], Aleksander Zidanšek[1,2,3], Uroš Cvelbar[1,2]

[1]Jozef Stefan Institute, Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

[3]Faculty of Natural Sciences and Mathematics, University of Maribor, Slovenia

The quantum Hall Effect is observed in two-dimensional electron systems at low temperatures and in strong magnetic fields, where the Hall conductance undergoes certain quantum Hall transitions and takes on the quantised values [1]. As the main reasons for Hall conductance in graphene, the influence of the magnetic field and adatoms have been studied. By tuning the magnetic field, one could also tune the electron-electron interactions in graphene. The quantum Hall Effect can be observed directly from the change in energy separations in the band spectrum. We also study the effects of spin-orbit interactions [2] on the plane of graphene with heavy transition metal atoms like niobium and ruthenium, for a case of an experimentally accessible low-temperature state, where spin-orbit potential converts graphene from an ideal 2D semi-metallic state to a Quantum Spin Hall insulator[3]. This new electronic state of graphene insulates at the bulk and allows spin and charge transport through the gapless edge states at the sample boundaries [3].

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Field-Assisted Sintering of Titanium Metal-Matrix Composites Reinforced with Carbon Nanotubes

Martin Topole[1], Elinor G. Castle[3], Michael J. Reece[3], Paul J. McGuiness[1,2]

[1] Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia
[2] Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia
[3] School of Engineering and Material Science, Queen Mary University of London, Mile End Rd, London E1 4NS, UK

Titanium, with its excellent corrosion resistance and high yield strength, is being used in various commercial applications where such properties are necessary (chemical industry, aeronautics). Even though it possesses the highest strength-to-density ratio of all the metallic elements, there are other properties where improvements would be very beneficial [1]. One of the routes to achieving improvements is to form titanium-based metal-matrix composites using carbon nanostructures, like carbon nanotubes (CNTs)[2], since they possess extraordinary electrical and mechanical properties and possess an extremely high thermal conductivity coefficient [3].

Commercially pure, spherical, titanium particles were mixed with multi-walled carbon nanotubes in accordance with (1-x)Ti–(x)CNT, where x = 0.1, 0.2, 0.5, 0.75 and 1.0 wt %. The mixing was performed in a planetary ball mill with a rotation speed of 300 rpm for 2 hours, a ball-to-powder ratio of 20 and with the addition of 2.0 wt % of stearic acid that acted as a surface-active agent. The composites were sintered with a field-assisted-sintering technique (FAST) at a temperature of 850 °C and an applied pressure of 16 kN for a duration of 10 minutes.

The microstructures of the compacts were analysed with optical and scanning electron microscopes (Figure 1) and their Vickers hardness values were measured according to the SIST EN ISO 6507-1 standard (Figure 2). The densities of the compacts were measured using Archimedes' method. Transmission electron microscopy (TEM) was used to determine the state of the CNTs inside the composites.

The results show successful compaction, even with such short sintering times, since the compacts were fully dense. The TEM analysis showed that the CNTs retained their tubular form and were dispersed around the particle boundaries. The Vickers hardness increased when more CNTs were introduced to the composite.

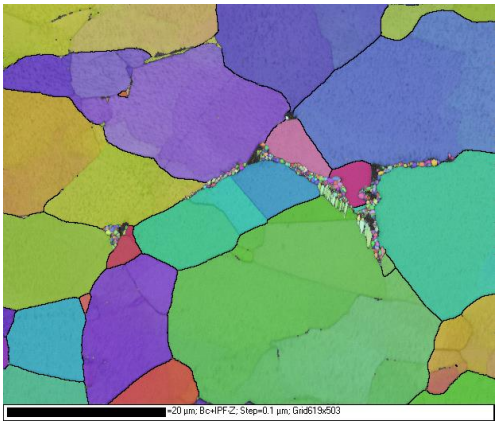

Figure 1: EBSD of the CNT-Ti metal-matrix composite

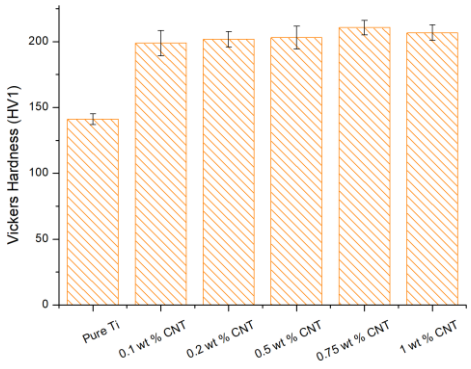

Figure 2: Vickers hardness of the samples produced with FAST

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Improvement of foamed glass production with the use of hydrated sodium silicate

Uroš Hribar[1,2], Matjaž Spreitzer[1], Jakob König[1]

[1]Advanced Materials Department, Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

Sustainability and energy efficiency are becoming increasingly important areas of research. One way to increase both is to prevent energy loss, which can consequently also lower the emissions of greenhouse gases. Buildings represent around 40% of all energy consumed in EU [1] and therefore should be made as energy efficient as possible. Insulation materials can prevent energy loss and market already offers a variety of them. Foamed glass is insulation material that has good insulating properties, is lightweight, non-flammable, bacteria- and water-resistant, porous material, which does not support mold growth and can at the same time offer a good amount of support to construction. Foamed glass is not as widely used as some other more traditional insulation materials [2], especially due to its price, which could be significantly reduced by using less pristine glass in the production process. Use of waste cathode ray tube (CRT) glass for the production of glass foam is a well-researched field which offers a solution to the high price problem and furthermore, is a part of solution for waste old TV screens [3]. The main industrially used process for production of foamed glass uses additives called foaming agents that produce gases inside the pyroplastic mass of glass, resulting in a porous product. Carbon and manganese oxide form a good foaming combination for production of foamed glass with desired properties, but in oxidative atmosphere carbon burns out, before material reaches its pyroplastic state. Since the idea of using waste glass is to reduce energy demand of foam glass production, it is desirable to use air atmosphere, which is oxidative. Thus, our work is focused on foaming of CRT waste glass with carbon and manganese oxide in oxidative atmosphere in a way that carbon will not react with atmosphere prematurely. Solution that we are researching is an addition of water glass, which by itself works as a foaming agent by releasing water vapors over a wide range of temperatures. Water vapors protect carbon from air atmosphere and reaction between carbon and manganese oxide can happen. However, the use of waste materials and new additives leads to attenuated properties, such as higher thermal conductivity.

Our research has shown that higher proportion of water glass in foaming composition leads to foams with lower densities. With the use of water glass, we produced foamed glass with density ~155 kg/m^3 and thermal conductivity of ~50 mW/mK (at ~21°C). Exploring and understanding the foaming mechanism, i.e. relations between temperature, glass composition, crystallization and gas-releasing reactions, could allow us to optimize additives and the process itself to improve properties of foamed glass and thus create a more sustainable and efficient insulation material.

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Influence of different oxygen plasma species on the growth of CuO nanowires

Martin Košiček[1,2], Gregor Filipič[1], Uroš Cvelbar[1,2], Oleg Baranov[3]

[1]Jožef Stefan Institute, F6 Department for gaseous electronics, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[3]Plasma Laboratory, National Aerospace University, Kharkov, Ukraine

In recent years, our group has been thoroughly investigating plasma assisted growth of metal oxide nanowires. Copper oxide was often chosen for that purpose due to its high potential in semiconducting industry. In one of the studies [1] copper plates were exposed to the oxygen and argon RF plasma, and it was found that dense array of nanowires formed towards the centre of the plates, while the nanowires were scarcely distributed towards the edges. This may be due to two reasons. First one is that while press-cutting the copper plates out of the foil, morphology of the samples on the edges was varied, which affected nanowire growth. The other explanation was that because of the curvature of the edges, electric field is much stronger there. Thus, surface around the edges is more prone to bombardment with the ion species present in the plasma. In addition, it was concluded that ion species limit the growth of nanowires in plasma due to sputtering effect, which was also confirmed by the developed theoretical model. The model was further developed in the next research [2] of nanowire growth in RF plasma, taking into account the experimentally determined lengths and aspect ratio of the nanowires. The conclusion of this study was, that ion species are actually essential for nanowire growth due to their catalytic properties in nanowire formation. Therefore, besides being the limiting factor in the nanowire growth, ions are also important for nanowire formation. To test this statement, we decided to conduct another study. In our present research, we are investigating if nanowires also form in plasma without the presence of ion species. In the preliminary study, we exposed copper plates to the afterglow area of microwave plasma, where no charged plasma species are present. In order to improve theoretical model and find parameters for Langmuir isotherm, which was used in the model, we also grew CuO nanowires by thermal oxidation. Preliminary results infer that plasma ion species are indeed necessary for CuO nanowires growth. However, some measurements, such as density of oxygen radicals in the afterglow area, have yet to be measured and included in the theoretical model developed, before conclusions can be made.

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Innovative development and manufacturing of magnet assemblies with enhanced corrosion resistance performance

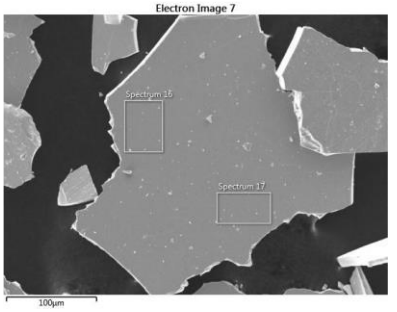
Ana Damnjanović[1, 2], David Jezeršek[1]

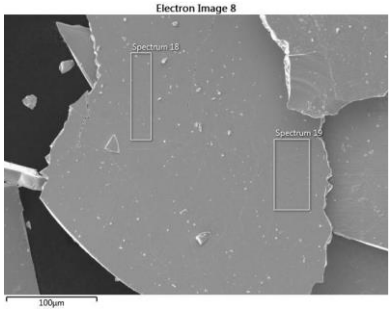
[1] Kolektor Group d.o.o., Vojkova ulica 10, SI-5280 Idrija, Slovenia
[2]Jožef Stefan International Postgraduate School, Jamova c. 39, SI-1000 Ljubljana, Slovenia

Modern rare earth based magnets have impacted the technological development in a great manner. Despite the fact mostly used rare-earth based materials are neodymium iron boron and samarium cobalt magnets, in this project the focus will be primarily on polymer bonded $Sm_2Fe_{17}N_3$. Although Sm-nitride magnets have higher Curie temperature, strong uniaxial anisotropy and superior magnetization [1], they are less used because their tendency to decompose into Sm nitride and α- Fe above 600 °C [2]. However, processing at temperature lower than 600 ^{0}C, also leads to formation of α- Fe phases due to oxidation-reduction reaction in the powder particles, which in turn diminish magnetic properties [3]. So far, various approaches were investigated regarding processing of the magnetic powders, to improve thermal instability and magnetic properties. The objective of this work is to modify the powder surface by coating magnetic particles.

The SEM/EDX analysis was done on isotropic powder particles of $Sm_2Fe_{17}N_3$, produced by melt-spun. Commercially available Sm-Fe-N powders produced by two different manufacturers were characterized, since in previous testing, one was more prone to corrosion. Both specimen have an average particle size of 250 μm. The fracture surfaces on both samples give the impression that the particles are three-layer and the analysis by individual layers show almost the same composition of all three layers. However, the powder with greater corrosion resistance had a higher Co content (about 3-4%).

Future work will include examination of uncoated and coated magnetic powder particles and bonded magnets. Specimen will be exposed to different corrosive environments (aqueous and oil-based fluids) and temperatures to determine magnetic properties, oxidation resistance, thermal durability and to study the corrosion mechanisms.





	EI7		E8	
Spectrum Label	Spectrum 16	Spectrum 17	Spectrum 18	Spectrum 19
Fe	64,06	62,53	61,90	63,30
Sm	20,97	20,21	19,49	19,64
N	3,72	3,32	3,83	3,67
Zr	1,39	1,41	1,43	1,41
Co	3,71	3,60	3,58	3,55
C	4,97	4,77	5,76	5,66
O		1,53	1,26	1,32
Ga	1,19	1,44	1,22	1,26
F		1,18	1,53	
Al				0,19
Total	100,00	100,00	100,00	100,00

Figure 1: (a) and (b) SEM micrographs of Sm-Fe-N powder with higher corrosion resistance, (c) elements found in the sample expressed in wt(%)

Acknowledgments: This project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 766007 project MAMI.

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Lipid droplets – cellular safeguards of stress-free life

Eva Jarc[1,2], Ema Guštin[1], Anja Pucer Janež[1], Vesna Brglez[1], Thomas O. Eichmann[3], Robert Zimmermann[3,4], Jana Gerstmeier[5], Oliver Werz[5] and Toni Petan[1]

[1]Department of Molecular and Biomedical Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
[3]Institute of Molecular Biosciences, University of Graz, Graz, Austria
[4]BioTechMed-Graz, University of Graz, Graz, Austria
[5]Friedrich-Schiller Institute, University of Jena, Jena, Germany

Lipid droplets (LDs) are conserved cellular organelles found in most organisms including bacteria, yeast, plants, insects and mammals. Their unique structure, a core of neutral lipids composed of triacylglycerols (TAGs) and cholesterol esters surrounded by a phospholipid monolayer embedded with proteins, requires specialized mechanisms for their formation, growth and breakdown.[1] They act as central cellular regulators of fatty acid (FA) uptake, storage, trafficking and consumption. LD biogenesis is induced in cells exposed to excess lipids and is characteristic of many contemporary diseases, such as obesity, diabetes and cancer. Paradoxically, their formation occurs also in cells fully deprived of nutrients and oxygen, suggesting that LDs are an integral part of the cellular stress response. We hypothesized that cancer cells, which are often exposed to stress due to imbalances in nutrients and oxygen, may use LDs as a stress resistance organelle that promotes cancer progression.[2] Indeed, we have reported previously that LDs protect breast cancer cells against starvation-induced cell death.[3] Here we found that aggressive breast cancer cells take up various fatty acids from their environment and store them in the form of neutral lipids in LDs.[4] These LDs are broken down when nutrients are scarce and the fatty acids are transferred into mitochondria to enable long-term survival of cancer cells. Moreover, we show that fatty acids released from LDs are converted into a range of eicosanoid signaling molecules, such as prostaglandin E_2, which is a known stimulator of cancer growth. Finally, we identified adipose triglyceride lipase (ATGL), a major TAG lipase in mammals, as the primary enzyme responsible for LD breakdown, fatty acid channeling to mitochondria and production of signaling mediators in breast cancer cells. These results strongly suggest that LD breakdown via ATGL activity is important for the remarkable resilience of some of the most aggressive breast cancer types. Collectively, LDs act through metabolic and signaling pathways and protect cells against stress making them attractive targets in the fight against cancer.

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Lipid droplets maintain membrane and organelle integrity and protect cancer cells from oxidative damage

Ana Kump[1,2], Eva Jarc[1,2], Špela Koren[1] and Toni Petan[1]

[1]Department of Molecular and Biomedical Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

For decades, lipid droplets were considered as passive cytoplasmic structures intended solely for the storage of fat in specialized cells, such as adipocytes and liver cells. However, recent studies have established that lipid droplets are organelles present in all eukaryotes from yeast to men, that they have a dynamic life cycle and display various roles in the cell. They act as regulators of lipid metabolism and trafficking according to different cellular needs, such as energy production in mitochondria and membrane synthesis during fast cell growth. Interestingly, increased lipid droplet biogenesis has been observed in cells exposed to nutrient and oxidative stress and they accumulate in various cancers. A recent study in flies found that incorporation of dietary polyunsaturated fatty acids (PUFAs) into lipid droplets protects neuronal cells from oxidative stress [1]. We have shown recently that aggressive breast cancer cells take up PUFAs, store them in lipid droplets and use them for energy production and cell survival during starvation [2]. However, we also found that excessive amounts of PUFAs cause cell damage and that their release from lipid droplets is toxic for the cell. Since cells incorporate fatty acids into cell membrane phospholipids and/or triglycerides stored in lipid droplets, we hypothesized that lipid droplets may have a protective role by shielding the easily oxidizable PUFAs from oxidation and reducing oxidative damage in cancer cells. We found that PUFA overload causes membrane and organelle damage associated with elevated oxidative stress and lipid peroxidation, which eventually results in the death of various cancer cells. The endoplasmic reticulum (ER), the principal organelle responsible for membrane and protein synthesis in the cell, was particularly sensitive to PUFA exposure. Importantly, pharmacological inhibition of lipid droplet formation potentiated the cell damage induced by PUFAs, leading to elevated reactive oxygen species production, lipid peroxidation and ER stress levels, and significantly increased cancer cell death. Our results thus suggest that lipid droplets are antioxidant organelles that protect cancer cells against oxidative stress by storing PUFAs and reducing oxidative damage to cell membranes and organelles. Lipid droplets thus emerge as potential targets for novel therapeutic interventions in cancer. Our future studies will determine whether interfering with the mechanism of lipid droplet biogenesis may weaken the resilience of cancer cells and reduce tumour growth *in vivo*.

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How azole corrosion inhibitors affect adsorption of corrosion relevant species

Matjaž Dlouhy[1,2], Anton Kokalj[1,2]

[1]Department of Physical and Organic Chemistry, Jožef Stefan Institute, Jamova c. 39, 1000 Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Jamova c. 39, 1000 Ljubljana, Slovenia

Corrosion is an inevitable natural chemical process with a tremendously negative impact on the economy and the environment. One of the methods used for mitigating the corrosion is the use of corrosion inhibitors, i.e., substances that have the ability to effectively reduce the corrosion rate already at very low concentrations. Although the precise atomistic mechanism of how inhibitors impede corrosion is usually not known, it is generally accepted that in the majority of cases inhibition is achieved through the interaction between corrosion inhibitor molecules and the surface of a metal, hence inhibitor–surface bonding has already been addressed by several computational studies from our group and those of others (see Ref. [1] and the references therein). However, as important as inhibitor–surface bonding might be, it is only one among possible inhibition mechanisms. Other factors are likely to contribute as well, such as lateral cohesive intermolecular forces and effects of inhibitor adsorption on surface electronic properties (e.g. work-function, band-gap). Kutej el al. [2] proposed an interesting indirect mechanism of corrosion inhibition that is similar to the role of poisons in heterogeneous catalysis, i.e., they pointed out that the inhibitor slows down the hydrogen evolution reaction by strengthening the bonding of $H_{(ads)}$ at sites that are within a given radius from the adsorbed inhibitor, thus impeding the desorption of H_2.

Hence, in this study, we explored the feasibility of the latter-type mechanism. To this end, we addressed, by means of DFT calculations, how adsorption of corrosion inhibitors affects the adsorption interactions of a few species that are relevant in corrosion, such as $O_{(ads)}$, $OH_{(ads)}$, $H_{(ads)}$, and $Cl_{(ads)}$; the first three are involved in typical corrosion reactions (oxygen reduction, hydrogen evolution), whereas the last is a typical corrosion activator. For the sake of definiteness, we chose benzimidazole and benzotriazole, which are known as outstanding corrosion inhibitors for copper and performed co-adsorption calculations on copper by utilizing the Cu(111) slab as a model of the surface. Our calculations reveal that among the considered species $O_{(ads)}$ is the most affected by the presence of inhibitors. In particular, both considered inhibitors significantly strengthen their bonding to the copper surface, which may indicate that inhibitors have the ability to stabilize the passive oxide layer. Inhibitors also strengthen the bonding of $Cl_{(ads)}$ but to a lesser extent than $O_{(ads)}$. In contrast, inhibitors weaken the adsorption bonding of $OH_{(ads)}$, whereas their effect on adsorption of $H_{(ads)}$ on Cu(111) is insignificant.

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Magnetic Noise Extinction through Single Domain Stabilization with Antiparallel Exchange Bias in Magnetoelectric Composite Sensors

M. Jovičević Klug[1], L. Thormählen, S. D. Toxværd[21], V. Röbisch[1], D. Meyners[1], R. Knöchel, M. Höft[2], E. Quandt[1], J. McCord[1]

[1]Institute for Materials Science, Kiel University, Kiel, Germany
[2]Institute of Electrical and Information Engineering, Kiel University, Kiel, Germany,

Magnetically induced noise is one of the major contributors to the limits of magnetically driven sensors. Main noise sources are domain wall movement and abrupt, irreversible magnetization changes [1]. To hinder these formations, specialized techniques such as exchange bias (EB) have been utilized in the past [2]. However, the concepts showed limitations in reducing the magnetic noise contribution within the sensors [3]. We present a novel concept named antiparallel exchange bias (APEB) that utilizes EB multilayer system with interchangeable antiparallel alignment of magnetization in the individual layers. We integrated this concept into composite magnetoelectric sensors that have previously shown noise limitations of magnetic origin [3]. We show a stable single domain configuration with negligible irreversible changes of magnetization during the operation of the sensors. Induction measurements specify a linear response of magnetization up to 1 mT AC fields and a very weak transversal signal, indicating high purity of opposing coherent rotation of magnetization in the individual layers. Further investigation with static and time-resolved magneto-optical Kerr microscopy in the working frequency of the sensors confirms such behavior. With electrical measurements the magnetic noise impact was evaluated with operation of the sensor at 10 Hz using magnetic frequency conversion (MFC) [4]. The sensors yield a significant improvement of the noise threshold as with the new APEB, sensors yield a noise level that is an order of magnitude lower compared to the previously best sensors with multilayer EB. Additionally, it was determined that even with the application of MFC, the developed sensors reach noise levels limited by the thermo-mechanical noise. These are also the first ME cantilever sensors to reach such low noise performance with MFC. The reduced noise and slightly lower signal output of the new sensors lead to an improvement of the limit of detection reaching values as low as 60 pT/√Hz at 10 Hz. The results represent an important breakthrough for the development of magnetoelectric sensors as well as other sensors and devices that utilize magnetic layers for their operation.

The presented results were obtained within the framework of the Collaborative Research Centre SFB 1261, funded by the German Science foundation (DFG).

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Magnetron plasma characterization by optical emission spectroscopy

Nastja Mahne[1, 2], Matjaž Panjan[1], Miha Čekada[1, 2]

[1]Department of Thin Films and Surfaces, Jozef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

Magnetron sputtering is plasma-based vacuum technique for the deposition of high-quality thin films. The technique is used in many technological areas such as photovoltaics, microelectronics, optics, machining and others. It can be used for the design of simple metallic thin films to more advanced nanostructured and nanolayered coatings that have various functional properties. The technique is highly flexible and scalable, it enables deposition of almost all elements from the periodic table. In the combination with reactive gases, magnetron sputtering enables fabrication of practically unlimited number of thin film compounds.

The sputtering process occurs when plasma is created in front of the magnetron. The characteristics of plasma therefore define the properties and quality of deposited thin films. The plasma density, degree of ionization and the plasma temperature are important parameters that can be controlled by the operational parameters of the discharge. In practice, there are different techniques used for the characterization of plasma. One of such techniques is called optical emission spectroscopy (OES). The technique is based on the examination of the light emitted from the plasma. Atoms and ions in the plasma, which are excited by the high-energy electrons emit light when they relax to lower energy states. The light from these transitions can be used to characterize the state of the plasma.

In my work, I have focused on the measurements of optical emission spectra of magnetron sputtering discharge and triode sputtering discharge. In the experiments, I used a titanium target, which was sputtered in argon atmosphere. I measured spectra for several pressures and discharge currents and compared them to tabulated values. The results of the measurements show different characteristic spectra. In both sputtering regimes, i.e., magnetron and triode, the spectral lines at lower wavelengths (i.e. close to UV) grow in the intensity when discharge current is increased and the pressure is kept constant. These lines, which belong to Ti I and Ti II, increase in comparison to the Ar I and Ar II lines. This means that with the increasing discharge current the concentration of titanium atoms and ions also increases. On the other hand, I observed that the gas pressure does not strongly affect the plasma properties.

In the future, I will characterize the plasma with another advanced plasma diagnostic technique. I will use energy resolved mass spectrometry to measure the energy distribution of ions. I will also employ electrical probes to measure the plasma potential and electron temperature. In addition to these measurements, I will use high-speed camera to learn more about the dynamics of the plasma. Based on these experiments I will be able to optimize the plasma-based sputtering processes and hopefully improve the quality of thin films.

Mechanism of Topochemical Conversion of $Bi_4Ti_3O_{12}$ Plates to $SrTiO_3$ Plates under Hydrothermal Conditions

Alja Čontala[1,2], Matjaž Spreitzer[1] and Marjeta Maček Kržmanc[1]

[1]Jožef Stefan Institute, Advanced Materials Department, Jamova cesta 39, 1000 Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

$SrTiO_3$ is a very interesting functional material [1,2]. Moreover, it is a good substrate for the epitaxial growth of other perovskites [3]. For example, in case of $BaTiO_3/SrTiO_3$ composite it is expected that $SrTiO_3$ influence the direction of the polarization of the $BaTiO_3$ layer growing on $SrTiO_3$. Due to the lattice strain such composite is expected to show enhanced piezoelectric properties. $SrTiO_3$ particles tend to grow in cube-like shape rather than in the plate-like shape, because of its's highly symmetric crystal structure and the lowest energy of (100) plane [4]. Therefore, preparation of plate-like $SrTiO_3$ nanoparticles is not an easy task and our approach to overcome these thermodynamic constraints is presented in this research. Growth in the cube-like shape could be avoided by topochemical conversion of $Bi_4Ti_3O_{12}$ template plates into $SrTiO_3$ plates [5]. We first performed this transformation under hydrothermal conditions [6]. Special attention was paid on the understanding of the influence of the reaction conditions on the crystal morphology and orientation of the final $SrTiO_3$ particles. Chemical pre-treatment of the $Bi_4Ti_3O_{12}$ plates was found to influence the surface chemistry of the template and consequently also affected the reaction pathway and determined the final morphology, which varied from $SrTiO_3$ nanocubes, frames to plates with maintained shape of the template Additionally, we observed that the conversion to $SrTiO_3$ predominantly starts at the edges of $Bi_4Ti_3O_{12}$ plate and continues laterally to the interior of the plate. During the transformation, the converted $SrTiO_3$ part resembled mesocrystalline assembly of smaller (100) oriented nanocrystallites, in which negligible remains of bismuth were present. Thorough understanding of the topochemical conversion mechanism from $Bi_4Ti_3O_{12}$ to $SrTiO_3$ under hydrothermal conditions is important for preparation of other $MTiO_3$ (M=Ba, Ca, Pb) perovskite nanoplates using this type of template and synthesis method.

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Metals and ceramics, competition or synergy

Matej Kocen[1,2], Petra Jenuš[1], Anže Abram[1], Saša Novak[1]

[1]Department for Nanostructured Materials, Jožef Stefan Institute, 1000 Ljubljana, Slovenia

[2]Jožef Stefan International Postgraduate School, 1000 Ljubljana, Slovenia

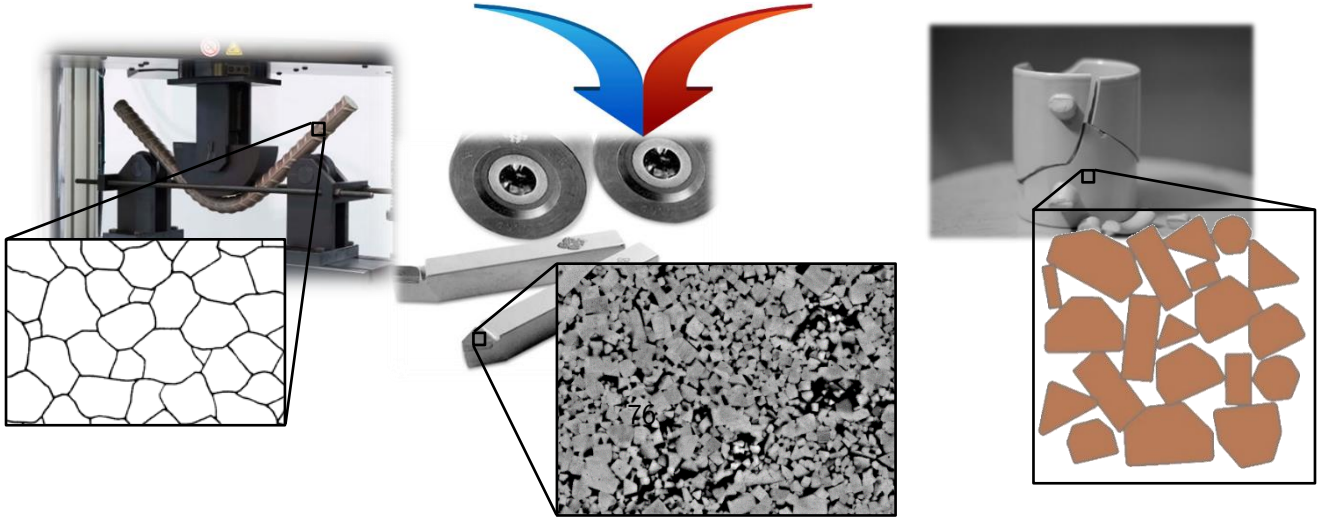
We are surrounded by different kinds/types of materials, every one with its own desired properties. Metals, for instance, are the building blocks of cities, withstanding great forces. That means they have high bending, tensile and/or compressive strength. But at some critical applied force, they tend to bend and irreversibly change their shape. This force gets even lower if the material is subjected to elevated temperatures.

Luckily, there are materials whose mechanical properties are not temperature dependent and that do not bend at applied forces. Ceramics are one of them. They also tend to be also less prone to oxidation compared with metals. Of course, ceramics do not excel metals in all characteristics. They are brittle, which means they break instantly if any minor crack stars to propagate through the material. Machining and shaping of these materials is also more difficult and costly.

This presents a question for many designers, workers and also researchers; which material is the best choice for a specific application? Either ductile/tough metal that bends or harder ceramic that might break? Will the two material groups compete with their properties or can we combine their strengths and present a superior material? The answer is yes. Composites, cemented carbides and/or cermets (ceramic + metal) are materials which fuse best properties of both metals and ceramics. Foundations of tall skyscrapers are made of concrete poured between steel rods to improve ductility and this is just one of the examples of the synergy of materials.

The same can be implied in material design for fusion application. The divertor of the fusion reactor has always been composed of pure tungsten (W). But because W recrystallizes at high temperatures (> 1000 °C), it will not meet the requirements for the next generation fusion powerplant (DEMOnstration power plant). The temperatures at divertor will reach temperatures well above 1000 °C, which pure tungsten will not withstand after exposure to high heat fluxes, neutron bombardment and sputtering of other light elements (deuterium, tritium, and helium). But also pure ceramics are not appropriate for this application, mainly because of its brittleness and also due to the low thermal conductivity of most ceramics.

The solution to this problem might lie in the combination of two. Using hard and temperature more stable ceramic matrix and the addition of metal binder phase for improvement of ductility and thermal conductivity. Proposal of our research group is to produce WC-based cemented carbides with the addition of low activation binder phase. One of the hardest and toughest materials known are WC cermets with the addition of cobalt. But due to high activation of cobalt, if exposed to a neutron, this material and all other materials with this property are not acceptable for plasma facing materials in a fusion reactor. Other possibilities are the use of nickel, iron or maybe even high-entropy alloys.



Overview of computational methods for processing MeV TOF SIMS spectra and 2D images at RBI

Marko Barac[1,2], Marko Brajković[1], Katherine L. Moore[1*], Zdravko Siketić[1], Iva Bogdanović Radović[1]

1Laboratory for Ion Beam Interactions, Ruđer Bošković Institute, Bijenička 54, HR-10000 Zagreb, Croatia
2International postgraduate school Jožef Stefan, Jamova 39, 1000 Ljubljana, Slovenia
**Permanent address: Department of Chemistry, University of Surrey, Guildford, Surrey, UK*

Complex, multivariate nature of MeV time-of-flight secondary ion mass spectroscopy (TOF SIMS) datasets requires the use of advanced statistical and machine learning methods for proper data interpretation (identification, classification or prediction). Such fast and efficient methods minimize subjectivity during analysis and use all the information available in the dataset. They improve signal to noise ratio and are able to remove potential bias. On the other hand, there are numerous different procedures to choose from, and some can be difficult to understand and interpret. Appropriate selection of data pre-processing and analysis method are critical for accurate interpretation of MeV TOF SIMS data. MeV TOF SIMS is a fairly new technique in use at heavy ion microprobe installed at the 45° beam line of the 6 MV Tandem Van de Graaff accelerator at RBI. So far it has been used in the analysis of forensic samples (mapping intersections of inks and toners, spectra of signatures and stamps, mapping of cocaine traces in fingerprints etc.) and biological samples (mouse serum and urine, liver tissue, biological cells etc.). This talk will cover the use and comparison of some of the computational methods, such as principal component analysis (PCA), non-negative matrix factorization (NMF), k-means clustering, multivariate empirical Bayes statistics (MEBA) in time series analysis and random forest, used in analysis of spectra and 2D images of mentioned samples.

Plasma-Assisted Synthesis of Oriented Carbon Nanostructures Using Resorcinol-Formaldehyde Resins

Neelakandan Marath Santhosh[1,2], Gregor Filipič[1], Uroš Cvelbar[1,2]

[1] F6, Gaseous Electronics, Jozef Stefan Institute, Ljubljana, Slovenia
[2] Jozef Stefan International Postgraduate School, Ljubljana, Slovenia

Oriented carbon nanostructures have attracted the research interest due to their unique orientation, morphology, open boundaries, electronic properties, large surface area and edge effects[1]. Plasma-assisted deposition techniques are considered as a promising method for the large-scale synthesis of oriented carbon nanostructures, which has an advantage of low-temperature and low-pressure growth conditions. This study explores the plasma-assisted technique for the growth of vertically aligned carbon nanostructures from a carbon precursor. Phenol derived polymer resins are promising carbon source for synthesising carbon nanostructures [2]. Resorcinol-formaldehyde (RF) polymer resin was used as a carbon precursor source in this study. A radiofrequency inductively coupled plasma was used for the synthesis process, where a thin layer of RF resin was cast on a glass substrate and placed in plasma. Argon and hydrogen gas species were used for the plasma discharge, and the surface treatment carried out at different time intervals (1-8 min). Structural changes that mainly occur on the surface of RF gel were investigated using scanning electron microscopy (SEM) and Raman spectroscopy. SEM images confirm the formation of oriented nanostructures and Raman spectrum displays the evolution of graphitic peak from the sample with respect to the plasma treatment, which confirms that the as-formed nanostructures are the derivatives of graphitic carbon. X-ray photoelectron spectroscopy (XPS) results explained the increase of carbon concentration on the sample surface with the plasma treatment time. Fourier-transform infrared spectroscopy (FTIR) results illustrate the chemical changes that occur during the plasma treatment on the RF gel. Combined analysis on FTIR and XPS reveals that the plasma treatment leads to the effective removal of functional groups from the structure, which improves the concentration of carbon in the structure. The obtained results support the assumption that plasma surface treatment on RF gel results in the formation of oriented carbon nanostructures by the recombination of carbon atoms and effective etching of amorphous carbon from the surface. Therefore, this process could be used as an effective technique for synthesising carbon nanostructure with controlled orientation.

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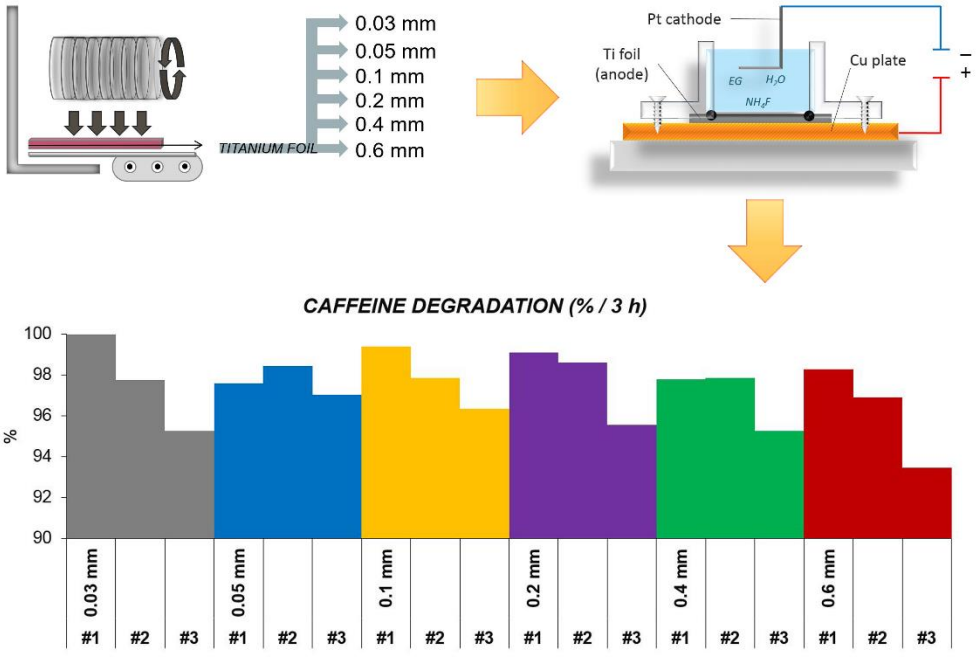
Substrate Thickness and Electrolyte Aging as Main Factors Influencing Photocatalytic Activity of TiO_2 Nanotubes

Živa Marinko[1,2], Luka Suhadolnik[1], Miran Čeh[1]

[1] *Department for Nanostructured Materials, Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia*

[2] *Jožef Stefan International Postgraduate School, Jamova 39, SI-1000 Ljubljana, Slovenia*

The ability to oxidize organic pollutants into innocuous compounds (H_2O, CO_2 and inorganic ions) is the main advantage of TiO_2 photocatalyst. With the band gap of approximately 3.2 eV, anatase TiO_2 has to be illuminated with UV light to initiate the formation of highly reactive species and start the photocatalytic degradation. In our work, firmly adhered TiO_2 nanotube films were grown with anodic oxidation of titanium of various thicknesses (0.03, 0.05, 0.1, 0.2, 0.4, 0.6 mm). We studied the influence of the titanium substrate thickness on the morphology and photocatalytic activity of TiO_2 photocatalysts. In addition, we focused on the observation of morphological changes of nanotubular films that occurred due to the repeated use of the same anodization electrolyte. Each thickness of titanium substrate was anodized with a completely fresh electrolyte, and with an electrolyte that was already used once or twice (three uses of the same anodization electrolyte in total). Changes in morphology occurred since the composition of the anodization electrolyte changed with repeated anodization process. Prior anodization a stylus profiler was used to determine the surface roughness and 3D profile of each foil. Scanning electron microscopy (SEM) was used to observe the morphology before and after each anodization. The photocatalytic activity of TiO_2 nanotube films was measured by caffeine degradation under UV irradiation with a high-precision UV-Vis-IR spectrophotometer. Results showed that both, electrolyte ageing and the thickness of titanium foil, greatly influence TiO_2 nanotubes morphology and their photocatalytic activity.



Wound healing using piezoelectric patch: preparation of PLA biocompatible films

Lea Udovč[1,2], Matjaž Spreitzer[1], Marija Vukomanović[1]

[1] Advanced materials Department, Jožef Stefan Institute, Ljubljana, Slovenia

[2] Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

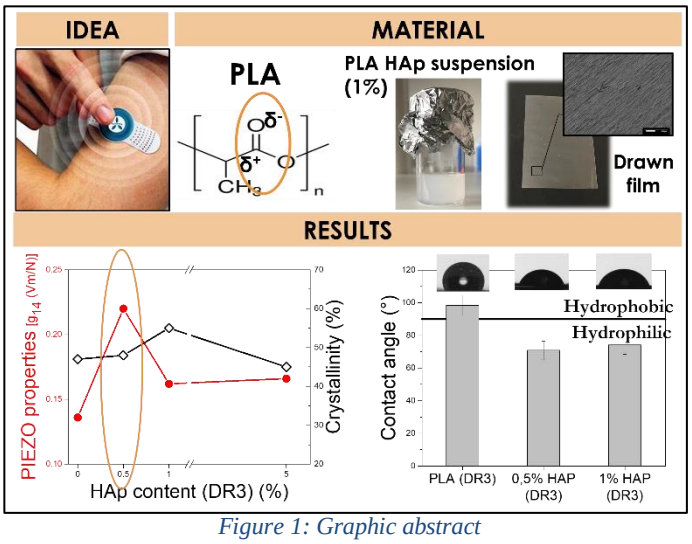


Figure 1: Graphic abstract

Every tissue scaring results in an immediate response of the organism, starting with the inflammatory phase which initiates a healing process, proceeding with proliferation and maturation phase. Any of the phases can be suppressed, due to bacterial infection, diseases, systemic problems, therefore healing can be prolonged or even unfinished. To accelerate these processes or to restart stopped healing, responsible for the occurrence of chronic wounds, different methods are used. One of the methods is the use of growth factors which cause many additional complications with optimization for each particular wound. The other already used invasive method is electric current wound healing of injured tissue. The alternative method, which we are studying is the use of piezoelectric material to trigger voltage difference, when the material is mechanically deformed by body movement [1] or by using medical ultrasound above the wound. Our goal is to prepare biodegradable piezoelectric film as a patch for medical application to accelerate wound healing process. We prepared a film composite of biodegradable polylactic acid polymer (PLA), as a piezoelectric component, and combined it with submicron particles of calcium hydroxyapatite (HAP) to improve biocompatibility and hydrophilicity of the whole film. For PLA to exhibit piezoelectricity, film needs to be crystalline with oriented polymer fibers, so when the polymer is mechanically deformed, C=O groups all orient themselves in one direction which create molecular dipole through the whole film. The film was prepared with uniaxial drawing to orient molecular chains and to achieve strain-induced crystallization. Films prepared with HAP particles are more hydrophilic than without the particles, particles improve piezoelectric properties, meaning that lower draw ratio (DR) is needed to achieve a maximal piezoelectric value of polymer. Since lower DR means lower crystallinity, also mechanical properties are improved, since polymer is more flexible and therefore appropriate for actual applications.

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Drugi programi (Other programs)

Aerosol deposition of relaxor-ferroelectric $0.9Pb(Mg_{1/3}Nb_{2/3})O_3–0.1PbTiO_3$ thick films onto low-cost metal substrates

Matej Šadl[1,2], Udo Eckstein[3], Neamul Hayet Khansur[3], Kyle Grant Webber[3], Uroš Prah[1,2], Barbara Malič[1,2], Hana Uršič[1,2]

[1]Electronic Ceramics Department, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia
[3]Department of Materials Science and Engineering, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen, Germany

A relaxor-ferroelectric $(1-x)Pb(Mg_{1/3}Nb_{2/3})O_3–xPbTiO_3$ (PMN-100xPT) shows excellent electro-mechanical properties, energy storage and energy conversion abilities suitable for electric generators, capacitors and electrocaloric cooling refrigerators [1, 2]. In order to miniaturize functional devices, the electroceramic components need to be scaled down to a micrometer level. The aerosol deposition (AD) offers a cost-efficient way to deposit dense micrometer thick films at room temperature, making possible the integration of ceramic components onto a low-melting point substrates, such as glasses, metals and polymers [3, 4].

In this work, the PMN-10PT thick films were prepared by AD for the first time. The powder was synthesized using mechanochemical activation, followed by additional milling and thermal treatment in order to obtain an optimized powder morphology and particle size distribution, which are crucial for a successful AD. We found that the milling time should be controlled carefully, since a prolonged milling can decrease the deposition efficiency of the powder. Figure 1(a) represents the PMN-10PT powder that was used for the deposition of 20 μm thick films onto low-cost stainless steel (Figure 1(b)). After the deposition, the films were post-annealed at 600 °C in order to improve the functional properties as previously reported for AD $Pb(Zr_{0.52}Ti_{0.48})O_3$ films [5]. As shown in Figure 1(c), the maximum polarization of prepared PMN-10PT films increases from 25 μC/cm² to 38 μC/cm² after a post-annealing at 600 °C. Furthermore, the films can withstand very high electric fields (i.e., 700 kV/cm) making them promising for high-field applications. To conclude, in this contribution the processing as well as functional properties of PMN-10PT thick films on low-cost stainless steel substrates will be discussed.

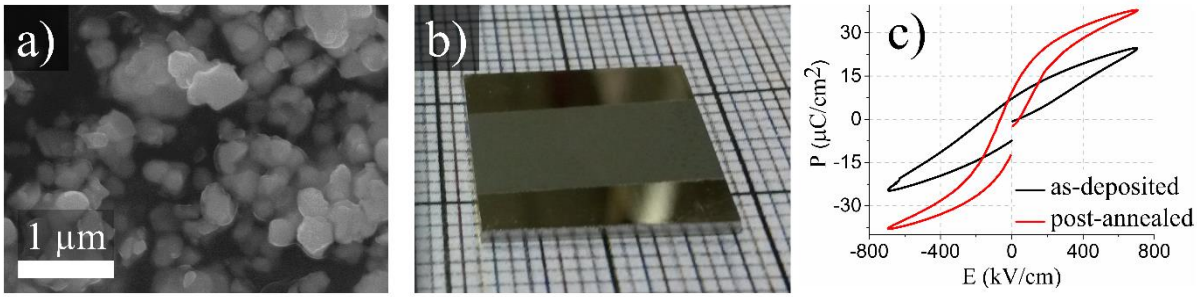

Figure 1. (a) Scanning electron microscope image of a characteristic powder morphology, (b) 20 μm thick PMN-10PT film deposited by AD on a stainless steel substrate and (c) polarization (P) vs. electric field (E) hysteresis loops of as-deposited and post-annealed films.

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Autonomous Learning of Bulb Insertion Using Environmental Constraints

Mihael Simonič[1,2], Bojan Nemec[1]

[1] *Department for automation, biocybernetics and robotics, Jožef Stefan Institute*
[2] *Laboratory of robotics, Faculty of electrical engineering, University of Ljubljana*

We propose to improve robotic learning of assembly tasks using information gained during disassembly. Transfer of knowledge obtained from disassembly was previously studied in the context of engineering education, where the analysis of how parts interact during disassembly was shown to be relevant for understanding the assembly process [1]. We consider the cases where the assembly task can be programmed as a reverse execution of the corresponding disassembly task and evaluate the hypothesis, that learning disassembly first is easier than direct learning of the corresponding assembly operation, given no previous knowledge about the nature of the task.

During the assembly the product passes consecutively from state to state, with the set of possible further actions more and more constrained, until the product is assembled. On the other hand, movement is highly constrained in early stages of disassembly. Our previous experiments have shown, that autonomous learning of environment-restricted tasks can be easier using policy-gradient reinforcement learning algorithms [2]. In this research, we have used hierarchical reinforcement learning instead. Note, that the process of disassembly can be viewed as escaping from a maze. Our hierarchical learning consists of a high level decision making and underlying lower level intelligent compliant controller, which uses environmental constraints to move only in possible directions to identify paths and crossways in a maze. The higher level algorithm then learns the best actions in the states, autonomously generated by lower level controller. The learned paths between states are encoded with dynamic motion primitives [3]. During the assembly motion sequences are executed in a reverse order. The proposed approach was verified on maze learning and autonomous learning of inserting a car bulb into the casing.

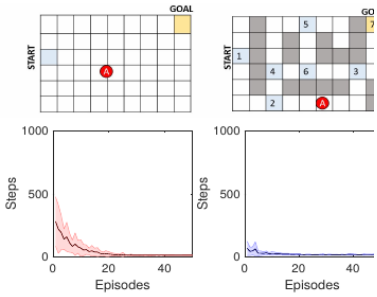

Figure 1: Upper row shows an empty maze and a maze with constraints (painted gray). Agent starts in blue state and learns the policy to arrive to the goal state (yellow). Bottom row shows that learning is faster in the constrained maze.

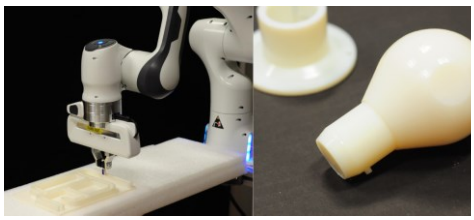

Figure 2: Experimental evaluation using the Panda robot by Franka Emika.

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Compositional study of lead-free sodium potassium niobate based piezoelectric ceramics

Oana Condurache[1,2], Kristian Radan[1], Brigita Kmet[1], Goran Dražić[1,2,3], Barbara Malič[1,2] and Andreja Benčan[1,2]

[1]*Electronic Ceramics Department, Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia*

[2] *Jožef Stefan International Postgraduate School, Jamova 39, 1000 Ljubljana, Slovenia*

[3] *National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia*

Nowadays, commercial piezoelectric ceramics are in majority lead-based. However, due to legislation and limitation of lead-based materials in commercial products, a big effort has been put into development of more environmentally friendly alternatives. High expectations are set for $(K,Na)NbO_3$ (KNN) based materials, since modified KNN has been found to exhibit piezoelectric performance comparable with the lead-based market leader. Among all the modified versions of KNN, $(K,Na,Li)(Nb,Ta)O_3$-$CaZrO_3$ with 2 wt% MnO_2 (KNLNT-CZ) reported by Wang et al. [1] gives a favorable combination of properties for piezoelectric applications: relatively high piezoelectric coefficient together with temperature-insensitive performance. Notwithstanding, there is plenty of room left for understanding the influence of the preparation route on the microstructure and chemical inhomogeneity and thus improving the piezoelectric properties of KNLNT-CZ. Radan et al. [2] showed that the mechanochemically-assisted (MCA) route [3] might have important advantages to the classical solid state synthesis.

In the present study, we go further and investigate the influence of adding MnO_2 either before or after the calcination step in KNLNT-CZ prepared by MCA. The microstructure and compositional aspects are discussed down to the atomic level using analytical scanning and transmission microscopy techniques. We prove that Mn-rich as well as Zr-rich secondary phases are present in both samples (Fig.1). Nevertheless, we show that adding MnO_2 after the calcination step contributes to a more homogeneous composition at submicronic level, correlated with a higher piezoelectric d_{33} coefficient.

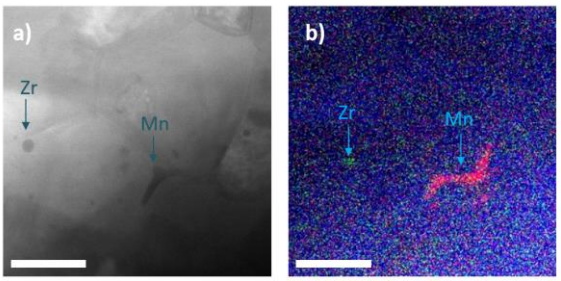

Fig.1 a) Scanning transmission electron microscopy image of polycrystalline KNLNT-CZ with 2wt% MnO_2 added before the calcination step with b) corresponding Energy dispersive x-ray spectroscopy mapping showing Mn and Zr segregations. Scale bar represents 500 nm.

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Cystatin F is expressed in glioblastoma

Emanuela Senjor[1,2], Milica Perišić Nanut[1], Barbara Breznik[3], Jernej Mlakar[4], Andrej Porčnik[5], Tamara Lah Turnšek[3], Janko Kos[1,2]

[1]Department of Biotechnology, Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia
[2]University of Ljubljana, Faculty of Pharmacy, Aškerčeva 7, SI-1000 Ljubljana, Slovenia
[3]Department of Genetic Toxicology and Cancer Biology, National Institute of Biology, Večna pot 111, SI-1000 Ljubljana, Slovenia
[4]Institute of Pathology, Medical Faculty, University of Ljubljana, Korytkova 2, SI-1000 Ljubljana, Slovenia
[5]Department of Neurosurgery, University Clinical Centre Ljubljana, SI-1000 Ljubljana, Slovenia

Glioblastoma is the most common brain tumor. It is characterised by aggressive, undifferentiated cells that diffusely invade the surrounding tissue. The tumor tissue comprises heterogeneous cell populations. In addition to tumor cells, we can find activated microglia cells, macrophages and tumor stem cells. Analysis of RNA microarray datasets in GlioVis database for brain tumors shows, that cystatin F expression is increased in glioblastoma. Cystatins are endogenous inhibitors of lysosomal cysteine peptidases. Cystatin F is a member of cystatin type II family that is synthesised and secreted as an inactive dimer. After proteolytic activation, it is converted to monomer that inhibits the activity of cathepsins L, S, H, and C. Even though cystatin F is secreted, it is not active extracellularly. A part of cystatin F is retained intracellularly and is targeted to endosomes/lysosomes. Secreted cystatin F can be taken up by neighbouring cells and can therefore regulate cysteine protease activity *in trans*. Cystatin F is generally expressed in immune cells, but its expression is altered in some pathological conditions like cancer and neurodegenerative diseases. The aim of this study is to examine the expression of cystatin F in glioblastoma and to analyse whether cystatin F expression can be induced also by tumor cells.

Formalin-fixed paraffin-embedded tissue of glioblastoma patients was used for immunohistochemical detection of cystatin F. As in vitro glioblastoma model we used U-251 MG cell line and U-937 pro-monocyte cells as a source of cystatin F. Effects of different co-cultivation periods and cell ratio between U-251 MG and U-937 cells on the expression of cystatin F were tested in whole cell lysates using non-reducing SDS PAGE and western blot analysis. The localization of cystatin F was analysed in formalin-fixed single cell layers using fluorescently labelled cystatin F antibody and confocal microscopy. The effect of co-cultivation on the activity of cathepsin L was also tested.

Our results show that cystatin F is present in glioblastoma tissue but not in healthy brains. We characterized the cells expressing cystatin F and found cystatin F in cells expressing tumor cellular markers (GFAP), stem cell markers (SOX2) and microglial markers (Iba-1). After co-cultivation with U-937 cells, U-251 MG cells contain cystatin F mainly in active monomeric form, localized in vesicular intracellular structures. Using paramagnetic beads we found that cystatin F co-immunoprecipitated with cathepsin L. Uptake of cystatin F inhibits the activity of cathepsin L in U-251 MG cells. Our future aim is to elucidate the role of cystatin F expression in glioblastoma.

Development of hydrogen peroxide gas sensor for security applications

J. Isailović[1], P. Jovanovič[2], V. Jovanovski[1],

[1] Department of Analytical Chemistry, National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia
[2] Department of Catalysis and Chemical Reaction Engineering, National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia

Concerns related to global security have given rise to increased research in the field of explosive detection, aimed at developing analytical methods for fast, sensitive, and simple determination of explosives in trace amounts [1]. Particular attention has been given to the peroxo-based explosives due to their increasing usage [2], the issue being that the standard chemical identification techniques are not suitable for peroxo explosives. Hydrogen peroxide, which is both precursor and degradation product of peroxo explosives, is a redox active compound prone to both oxidation and reduction. This implies that electrochemical techniques offer themselves as a prime choice in detection of peroxide-based explosives [3].

When designing gas electrochemical sensors the electrode surface has to be modified to achieve high electrocatalytic properties. There are several possible ways to achieve this, for example modification of the electrode surface with an insoluble redox active complex such as iron(III) hexacyanoferrate(II), known as Prussian-blue or its mixed metal analogues [4]. They could be considered as an artificial peroxidase and redox mediator for efficient shuttling of electrons between the electrode surface and the H_2O_2 molecule, obtained by degradation of the peroxo explosive [5]. Furthemore, besides electrocatalytic properties of the surface modified electrode, the overall performances of H_2O_2 electrochemical gas sensors depends on the electrochemical technique applied, i.e. the excitation protocol in the course of the operation of the sensor. In this context, better outcomes can be achieved with advanced voltammetric techniques such as fast scan cyclic voltammetry and square-wave voltammetry [6].

Our current investigation has been focusing on the development of semi-solid electrolytes comprising several functions: **i)** accumulation of the analyte from the gaseous phase thus considerably improving sensitivity, **ii)** derivatization of the gas analyte facilitating more accessible electrochemical detection or even chemical derivatization of electrochemically inactive compounds into electrochemically active ones and finally, **iii)** semi-solid ionic electrolyte offering rapid diffusion of the analyte to the electrode surface. Recent results along these lines and in terms of electrochemical detection of gaseous H_2O_2 will be discussed.

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Interaction between ammodytoxin, a neurotoxic snake venom secreted phospholipase A_2, and neuronal mitochondria

Adrijan Ivanušec[1,2], Jernej Šribar[1], Peter Veranič[2], Igor Križaj[1]

[1]Department of Molecular and Biomedical Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia

Secreted phospholipases A_2 ($sPLA_2$) are a group of enzymes secreted by cells that hydrolyse glycerophospholipids to *sn*-2 lysophospholipids and fatty acids. They have been described from viruses to mammals, being implicated in many physiological and pathological settings, such as innate immunity, asthma, atherosclerosis, inflammatory diseases, Alzheimer's disease, neuritogenesis, neurotransmitter release and various forms of cancer. They can also be found in snake venoms, where they act as β-neurotoxins (β-ntxs), meaning that they block neuro-muscular transmission by poisoning nerve terminals, causing flaccid paralysis. Damage inflicted by such β-ntxs on neuronal mitochondria is characteristic, very similar to that induced by structurally homologous endogenous group IIA $sPLA_2$ (GIIA $sPLA_2$) when its activity is elevated, as, for example, in the early phase of Alzheimer's disease. This similarity of GIIA $sPLA_2$ and β-ntxs suggests they also share some similarities in their action on the molecular level. While the molecular mechanism of this action of GIIA $sPLA_2$ is not known, the β-ntxs have been better studied in this respect and might be used as tools for revealing the former. In that regard, a high affinity membrane receptor for ammodytoxin (Atx), a β-ntx from the venom of the nose-horned viper (*Vipera a. ammodytes*), was detected in neuronal mitochondria and identified as the subunit II of cytochrome c oxidase (CCOX-II), an essential constituent of the respiratory chain complex [1]. It was shown that Atx inhibits CCOX activity when incubated with isolated mitochondria. The exact mechanism of this inhibition and how β-ntxs translocate into mitochondria, however, remains to be investigated. To study these processes we have expressed and isolated an enzymatically inactive mutant of Atx and labelled it with 5 nm NHS-activated gold nanoparticles. We are using this molecular tool for localization studies by electron microscopy, investigating internalization of Atx into a neuron-like model cell line and its translocation into mitochondria. Altogether, the results suggest the explanation of the mechanism by which β-ntxs hinder the production of ATP in poisoned nerve endings and open an important direction of study to advance the understanding of the mitochondrial function and dysfunction of endogenous GIIA $sPLA_2$.

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Proteins binding to antisense transcript from *C9orf72* gene mutation

Mirjana Malnar[1,2], Simona Darovic[1], Maja Štalekar[1], Boris Rogelj [1, 3, 4]

[1] Department of Biotechnology, Jožef Stefan Institute, Ljubljana, Slovenia

[2]Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia

[3]Biomedical Research Institute, BRIS, Ljubljana, Slovenia

[4]Faculty of Chemistry and Chemical Technology, University of Ljubljana, Ljubljana, Slovenia

Mutation in *C9orf72* gene occurs in non-coding region of the gene and is presented as increased number of polymorphic hexanucleotide repeats of GGGGCC. While healthy individuals have up to 23 repeats, presence of several hundred or several thousand repeats is the most common genetic cause of two neurodegenerative diseases - amyotrophic lateral sclerosis (ALS) and frontotemporal dementia (FTD). ALS and FTD are incurable and progressive diseases, and are close on clinical, neuropathological and genetic spectrum. While mechanisms of their development and progression are still not entirely known, mutation in *C9orf72* gene causes up to 40% of hereditary ALS cases and 25% of hereditary FTD cases.

So far, there are three potential mechanisms, which are not mutually exclusive, proposed for the impact of *C9orf72* mutation on disease development and progression. First possible consequence of the mutation is reduction in expression of the gene leading to haploinsufficiency of C9orf72 protein. The polymorphic hexanucleotide repeats of GGGGCC can be transcribed to RNA, which is proposed to be toxic for the cell on the account of sequestering RNA binding proteins important for normal cell functioning. This RNA can also be transcribed into proteins with dipeptide repeats (DPRs), which are also to be toxic for the cell.

Our aim is to investigate impact of antisense RNA transcripts from the mutation on the development and progression of ALS and FTD. The extended hexanucleotide repeats of GGGGCC are transcribed into RNA in the sense (G_4C_2) and antisense (C_4G_2) form. Both sense and antisense transcripts form different secondary structures; G-quadruplexes are formed by sense and i-motifs by antisense transcripts. As a result, these RNA transcripts form mostly nuclear RNA foci in spinal cord and brain neurons of C9 ALS/FTD patients, where they could sequester RNA binding proteins and, therefore, interfere with their function. Described impact of RNA foci was also observed in other diseases associated with RNA transcripts of repetitive sequences, such as myotonic dystrophy. In our research we have identified several proteins binding to the antisense (C_4G_2) transcripts, which could impact overall cell protein synthesis as well as cell skeleton stability and, consequently, transport of cargo to neuron synapses. We will present these latest findings as all the mentioned mechanisms could be detrimental for normal function of neurons as well as neuron survival, and, therefore, for disease development and progression.

Screening for new surface anchoring domains for *Lactococcus lactis*

Tina Vida Plavec[1, 2], Aleš Berlec[2]

[1]University of Ljubljana, Faculty of Pharmacy, Aškerčeva 7, Ljubljana, Slovenia
[2]Department of Biotechnology, Jožef Stefan Institute, Jamova 39, Ljubljana, Slovenia

Lactic acid bacteria (LAB) are considered valuable host organisms in biotechnology due to their long-term usage in food, industrial applicability and beneficial influence on health (probiotic properties). Because of its "generally recognized as safe" status, LAB *Lactococcus lactis* represents an attractive host for surface display and a promising vector for *in situ* delivery of bioactive proteins. The use of bacteria with surface displayed recombinant proteins is applicable in numerous biotechnological applications. Surface displayed recombinant protein is usually anchored to the cell wall of LAB through an anchoring domain. Different types of surface anchoring domains have been described for LAB, LPXTG-type domains and lysin motif (LysM) being among the most frequently applied in *Lactococcus lactis*. Regardless of the available options, alternative surface display approaches are being sought to achieve stronger anchoring and binding through different mechanisms. The goal of the present study was to characterize new anchoring domains for surface display on *Lactococcus lactis* and evaluate their applicability for use as an alternative to already known anchoring domains, especially the commonly used C-terminal domain of AcmA (cAcmA), which allows non-covalent binding. We prepared genetic constructs consisting of secretion signal, reporter protein (B domain of staphylococcal protein A or DARPin) and surface anchoring domain of lactococcal or phage origin. 13 different anchoring domains were tested, all of them binding to the bacterial surface through a non-covalent bond. Additionally, covalent binding LPXTG domains of two different lengths were included as a comparison. One of the tested domains, a phage anchoring domain, AM12, demonstrated comparable extent of surface display to that achieved with cAcmA. In further studies, AM12 enabled display of CXCL8-binding evasin-3 on *Lactococcus lactis*, as well as heterologous display, to a level similar to that achieved with cAcmA. To conclude, we have demonstrated effective use of different protein anchors in *Lactococcus lactis*. AM12, especially, represents a promising alternative to well-known approaches for surface display on *Lactoccocus lactis*.

Testing the sample preparation procedures and analytical techniques for radiometric dating, using Rb and Sr isotopes

Dominik Božič[1], Matej Dolenec[1], Aleš Šoster[1], Adrijan Košir[2], Janja Vidmar[3], Darja Mazej[3], Stefan Marković[3], Leja Rovan[3], Janez Ščančar[3], Marko Štrok[3]

[1] Dept. of Geology, Faculty of Natural Sciences, Aškerčeva 12, 1000 Ljubljana, SI
[2] Ivan Rakovec Institute of Palaeontology, Novi trg 2, 1000 Ljubljana, SI
[3] Dept. of Environmental Sciences, Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, SI

Radiometric dating enables geologists to establish absolute age of certain geological events. One of the simplest methods uses decay of ^{87}Rb to ^{86}Sr. Such dating can be achieved by determining isotope ratios of $^{87}Rb/^{86}Sr$ and $^{87}Sr/^{86}Sr$. Before such attempt, the sample preparation procedures and analytical techniques should be validated.

Two sample preparation procedures in combination with two analytical techniques were tested. The first procedure was chemical dissolving of samples and their analysis on Nu plasma II (Nu instruments Ltd, UK) multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS). The second procedure was ablation of samples on Analyte G2 (Teledyne Cetac, NE, USA) laser ablator (LA) and analysis on Agilent 8800 (Agilent Technologies, CA, USA) plasma mass spectrometer with triple quadrupole (ICP-QQQ). In order to evaluate the procedures and analytical techniques, the age produced by them was compared to known ages of crystallization, metamorphosis or deposition of geological samples. These were igneous rocks (monzodiorite, trachybasalt scoria), metamorphic rocks (gneiss), meteorites (chondrites) and fossils (Mollusca).

For MC-ICP-MS analysis the mineral phases were crushed to a diameter of less than 2 mm and manually separated. Afterwards, they were dissolved in HNO_3, HF, HCl, and H_2O_2. The separation of Rb and Sr was carried out using the Sr-Resin. The LA-ICP-QQQ analysis required little preparation, apart from cutting thin sections, polishing them and identifying the mineral phases with an optical or electron microscope.

Our igneous rocks turned out to be likely too young for measurement by means of chemical dissolving and analyzing on MC-ICP-MS, since there was not enough time for the formation of daughter isotopes. Measurements of fossils were accurate down to ± 20 Ma. The calculated age of the last tested metamorphic sample was 279 Ma, whereas the corresponding values found in literature were in the range between 232 and 286 Ma. Previously observed $^{87}Sr/^{86}Sr$ ratio of the tested extrusive rocks is 0.7036, in our case it was 0.7053. Results obtained by LA-ICP-QQQ showed that used procedure, due to some mechanical malfunction at the time, could not provide results consistent enough for dating of material as young as Paleozoic. Therfore the only suitable sample was the meteorite, with it's age of 4.6 Ga. But still our measured age was overestimated by 200 Ma at 4.8 Ga.

Tested combinations of preparation procedures and analytical techniques are accurate to described degree, but at this time we conclude that current inability for continuous reproduction of such results makes it unsuitable for routine applications in the field of geochemistry or stratigraphy. We already can point to the areas that need improvement and can already come up with the solutions.

The sensor hub for detecting the influence of colors on reading in children with dyslexia (EEG, EDA, ECG, eye tracker)

Tamara Jakovljevic[1], Gregor Papa[2], Vanja Kovic[3], Milica Jankovic[4], Andrej Savic[5], Tadeja Jere Jakulin[6], Petar Todorovic[7]

[1]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana
[2]Jožef Stefan Institute, Computer systems
[3]Faculty of philosophy, Department for psychology, University of Belgrade
[4]Electrotechnical faculty, University of Belgrade
[5]Electrotechnical faculty, University of Belgrade
[6]FTŠ Turistica, UP
[6]Faculty of mechanical engineering , University of Kragujevac

In practice, alternative medical treatment by using colors proved to be very effective in solving the problem of dyslexia. According to the International Association of Dyslexia, dyslexia is characterized by difficulties with accurate and/or fluent word recognition and poor spelling and decoding abilities and "developmental dyslexia" is often used as a synonym for reading disability. In previous studies, it has been found that changing the color of the background for reading and writing can accelerate progress towards overcoming the problem of dyslexia. Color has been used in reading tasks with dyslexic subjects in a number of different ways and for different purposes. Colors produce different physiological responses in blood pressure, heart rate, respiration, digestion, body temperature, and brain activity. In the study "Good Background Colors for Readers: A Study of People with and without Dyslexia" is shown that warm colors, i.e. peach, orange, and yellow lead to significantly faster readings, while cool colors, blue-grey, blue, and green, lead to significantly longer reading times. There is also a lot of studies which measure the significance of font type, size on reading in children with dyslexia. Our goal is to use sensors for monitoring physiological parameters (electrical activity of the brain, heart rate, elector dermal activity and eye movement) and find the correlation between changes in colors and those parameters in order to better understand the reading process in children with dyslexia and how o improve their abilities to read normally. Dyslexic individuals exhibit a longer duration of fixations, shorter saccades and thus more fixations in reading than normally developing readers of the same chronological age. Such eye movement disorders have been reported in different languages, irrespective of their degree of transparency. In purpose of the the research study is created a sensor hub of 4 synchronized devices: Smarting (small, simple and mobile EEG device, which supports synchronization with other sensors and simultaneous multi-amplifier streaming via lab streaming layer), EDA (electro dermal activity sensor), Heart rate (ECG) and Eye tracking (IMotions sensor). In this article are shown the results of the first phase of the research, in which took part about 50 children (second and third grade of elementary school) with no reading disabilities, which have read one story in 13 paragraphs in a different font and background color. In the next phase, parameters will be measured (with the same set of sensors) during the reading process of children with dyslexia. The ultimate goal is to develop an application or sensor set that can quickly and accurately determine which color are suitable for an individual person, based on the value of the physiological measurements.

"Cutting the entropy crisis" using environmental friendly corrosion inhibitors on aluminum

Dževad K. Kozlica[1,2], Ingrid Milošev[1]

[1]Jožef Stefan Institute, Department of Physical and Organic Chemistry, Jamova c. 39, 1000 Ljubljana

[2]Jožef Stefan International Postgraduate School, Jamova c. 39, 1000 Ljubljana

Despite the first law of thermodynamics which states that energy cannot be created nor destroyed, it is often said that we are in an energy crisis due to the lack of energy in the world societies. In fact, what really matters is the quality of energy and it should be considered as the second law of thermodynamics which postulates that the entropy of the universe always increases. Thus, we are actually moving towards an entropy crisis, not an energy crisis [1]. Corrosion processes are the ones in which matter and energy tend to disperse, decreasing the quality of energy (i.e. increasing the entropy) which has the enormous impact on the economy. Therefore, retardation of corrosion processes eventually saves financial means invested in protection and maintainance of »matter«.

Aluminum and aluminum alloys have been widely used in automotive and aerospace industry because of their high strength-to-weight ratio, lightness and cost. With a standard potential of -1.66 V, aluminum does not belong to the noble metals but the formation of a few nm thick Al_2O_3 passive layer makes it very inert in many electrolytes. Chloride containing medium, however, is highly aggressive to Al and a corrosion protection is required. One approach to preventing the corrosion (i.e. cutting the entropy crisis) is the use of corrosion inhibitors. Efficiency of corrosion protection using inhibitors is dependent on the chemical structure of the inhibitor compound but also on the type of metal substrate, as well as its appropriate surface preparation [2, 3]. We have chosen two inhibitors, 2-mercaptobenzimidazole and octylphosphonic acid, which differ in their affinity for aluminum.

The selection of appropriate pretreatment method may play a significant role in adsorption of inhibitor molecules on the metal surface affecting the composition and corrosion properties of thus modified surface layer [4]. To investigate this issue further, we tested two different pre-treatments including mechanical and chemical pre-treatment of alkaline etching and acid desmutting. After pre-treatment, Al substrates were tested in aqueous NaCl solution with and without added inhibitors.

Electrochemical measurements revealed the differences in the inhibitory action of the compounds regarding the type of functional group and preparation of substrate. The efficiency of mercapto and phosphonate corrosion inhibitors on Al substrates was correlated to surface composition, wettability and roughness of the metal surface, as verified by ATR-FTIR spectroscopy, water contact angle and 3D-profilometry measurements.

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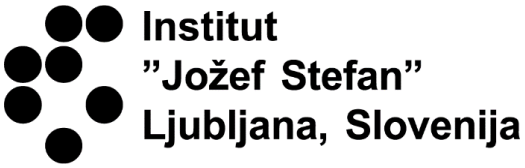

Naložbo št. 2130-17-090102 sofinancirata Republika Slovenija in Evropska unija iz Evropskega sklada za regionalni razvoj.

Jožef Stefan International
Postgraduate School

Jamova cesta 39
SI-1000 Ljubljana
T: +386 1 477 3100
F: +386 1 477 3110
info@mps.si
www.mps.si

Institut "Jožef Stefan"

Jamova cesta 39
SI-1000 Ljubljana
T: +386 (0)1 477 3100
F: +386 (0)1 477 3110
info@ijs.si
www.ijs.si