NATIONAL INSTITUTE OF **CHEMISTRY**

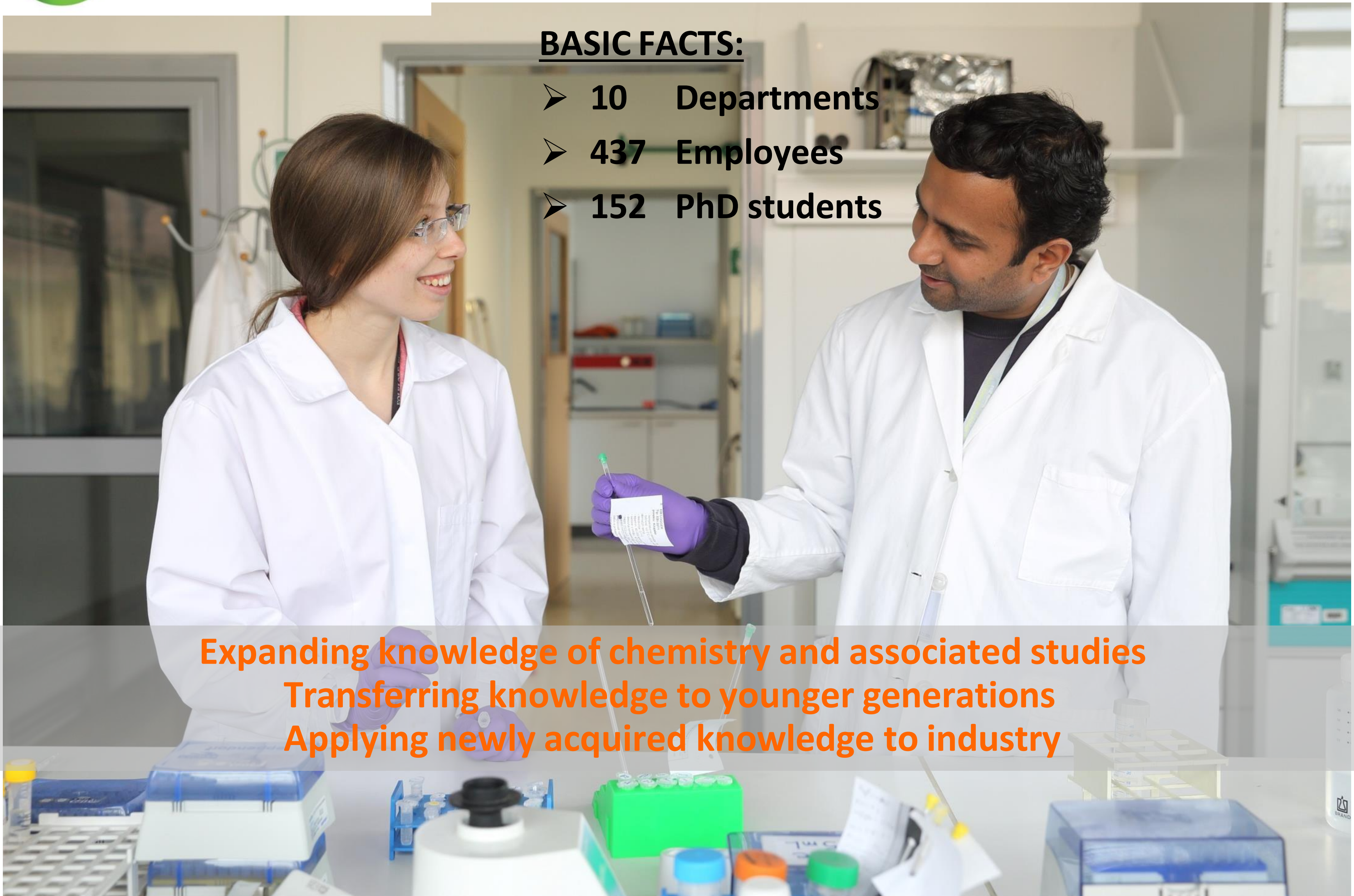
NATIONAL INSTITUTE OF CHEMISTRY

BOOST YOUR CAREER WITH MSCA POSTOCTORAL FELLOWSHIP AT THE NATIONAL INSTITUTE OF CHEMISTRY, SLOVENIA

HORIZON EUROPE
MARIE SKŁODOWSKA CURIE ACTIONS
POSTDOCTORAL FELLOWSHIPS CALL 2024

NATIONAL INSTITUTE OF CHEMISTRY

Mission



BASIC FACTS:

- **10 Departments**
- **437 Employees**
- **152 PhD students**

Expanding knowledge of chemistry and associated studies
Transferring knowledge to younger generations
Applying newly acquired knowledge to industry

NATIONAL INSTITUTE OF CHEMISTRY

Areas of research

With excellent research...

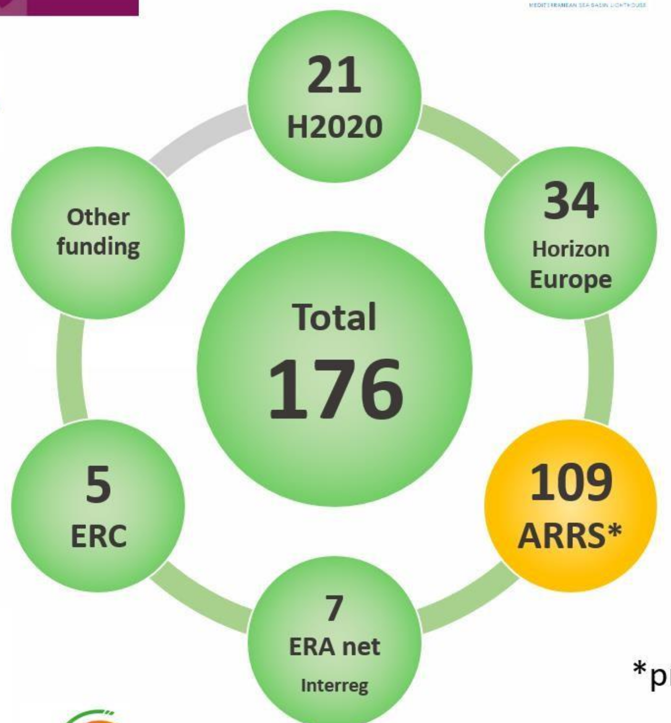
- Biotechnology
- Life sciences research
- Analytical chemistry
- Nanotechnology
- Food chemistry
- Energy
- Theoretical and structural chemistry
- Chemical engineering
- Materials research

Societal challenges

- Health
- Environmental protection
- Circular economy
- Sustainable energy
- Climate change
- Food safety
- Highly qualified people

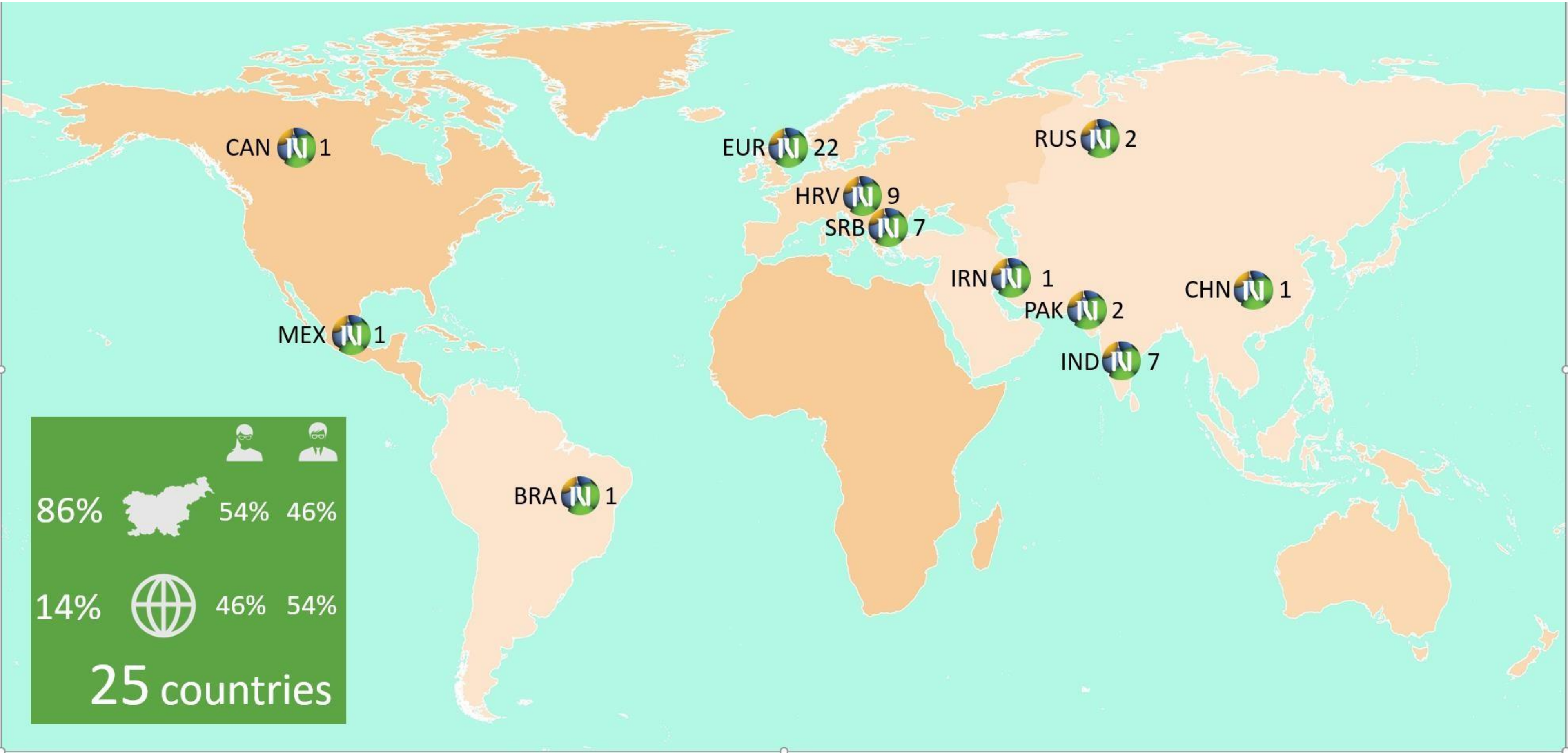
...we create new knowledge and help solving societal challenges.

Projects 2023



*projects and programmes

Foreigners


CAN 1
EUR 22
RUS 2
HRV 9
SRB 7
IRN 1
CHN 1
PAK 2
MEX 1
IND 7
BRA 1
86%
54% 46%
14%
46% 54%
25 countries

NATIONAL INSTITUTE OF CHEMISTRY

Expanding knowledge of chemistry and associated studies

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SUPERVISOR

Dr. Maja MARUŠIČ

More information

TOPIC 1

Structural studies of biomolecular condensates

Membraneless organelles or biomolecular condensates are formed by networks of specific proteins and RNAs. Due to dynamic and adaptable nature of condensates the process of their formation via phase-phase separation must be tightly controlled or it can lead to formation of pathological condensates. We aim to systematically explore how structure, dynamics and interactions of RNA are responsible for physical characteristics and biological role of RNA in various condensates, using in vitro reconstituted systems in combination with methods of structural biology.

SUPERVISOR

Assist. Prof. dr. Ivan JERMAN

More information

TOPIC 2

Beyond state-of-the-art high solar absorptivity coatings for tower CSP

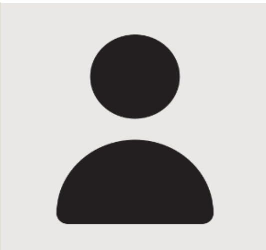
United Nations General Assembly explicitly recognised the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights. Organic and inorganic contaminants can enter drinking water from various sources, including industrial discharge, agricultural runoff, sewage effluents, and natural geological processes. Moreover, microbes and viruses are everywhere. Photo-catalytic degradation can be effective in removing a wide range of organic, inorganic and microbial contaminants from drinking water and different surfaces. Development of semiconducting oxide, graphitic carbon nitride and binder materials for optimal photocatalytic activity will be the core of proposed work. Only sustainable, mechanically and photo-active stable materials have chance to fulfil the demands of industry.

TOPIC 3

Photocatalytically active coatings for sustainable water supply

Concentrated Solar Power (CSP) plants emerge as a compelling and highly attractive solution for the future, which can store energy in the form of heat, allowing it to be converted into electricity. Increased efficiency, longer operational lifespans, increased thermal storage capacity, decreased Levelized Cost of Energy, and reduced environmental footprint all contribute to the improving of CSP plant dispatchability and lowering GHG emissions. In the frame of the project high absorptivity and high-temperature stable coatings will be developed for the receiver tubes, enabling them to operate at temperatures up to 850°C. This will facilitate achieving salt mixture temperatures inside the receiver tubes of 750°C for chloride-based mixtures and 800°C in the case of carbonate-based mixtures. The coating will be modified by adding particles, surface texturing (by laser and engineering particles) and addition of ceramic materials that withstand operating conditions up to 850°C, as well as other harsh conditions that the receiver must support, such as (extreme temperature cycling, humidity, erosion, etc.).

SUPERVISOR



TOPIC 4

Advancement of LA-ICP(TOF)MS capabilities and it's application to real world problems

The Laser ablation inductively couple plasma mass spectrometry has witnessed a kind of renaissance in the recent years, but there are still some persisting problems i.e. exact calibration, speciation... Which we are solving in our laboratory. A successful candidate will join our team in the endeavour. These findings will be then applied in the field of life sciences, geology, cultural heritage in collaboration with our research partners in Slovenia and Europe.

Dr. Martin ŠALA

More information

SUPERVISOR

TOPIC 5

Protein aggregation monitored by vibrational spectroscopy

Research into the behaviour of complex biological systems based on physical and chemical principles is an important scientific goal in the field of biosciences. Understanding the structure and internal dynamics of biomolecules, especially proteins, is central to deciphering the mechanisms underlying their biological functions. Our research aims to investigate the structural and dynamic processes in biomolecular systems and to clarify how they are influenced by inter- and intramolecular interactions. Specifically, we pursue two main objectives: firstly, to investigate the influence of hydrophobic/hydrophilic hydration on protein folding and aggregation, and secondly, to study the effects of the local environment on a protein's propensity to aggregate. It is a major challenge to decipher how observable biomolecular phenomena that span large temporal and spatial scales emerge from events at the molecular level. Therefore, we propose a comprehensive approach that combines experimental and computational methods. To achieve these goals, we have developed and utilised sophisticated spectroscopic techniques, including linear infrared, Raman and VCD spectroscopy and cutting-edge 2-D fs infrared spectroscopy (2-DIR) together with robust analytical tools from equilibrium and non-equilibrium statistical mechanics. In protein research, innovative techniques are constantly being sought to interpret the complicated structures and dynamics of proteins. Spectroscopic methods have proven invaluable in providing insights into molecular structures, folding pathways and intermolecular interactions. However, conventional methods often reach their limits when studying complex biological systems due to spectral overload and overlapping signals. 2-DIR proves to be a promising tool to overcome these challenges. By simultaneously utilising the frequency and time domains, this technique provides a comprehensive spectral fingerprint that enables the resolution of overlapping signals and the extractionof detailed structural information. In the context of protein research, this capability holds immense potential for elucidating the dynamics of hydrophobic interactions, which play a crucial role in protein folding, stability and function.

Prof. dr. Jože GRDADOLNIK

More information

SUPERVISOR

Doc. dr. Ilja Gasan OSOJNIK ČRNIVEC

More information

TOPIC 6

Electromagnetic-responsive supramolecular enzyme carriers for low temperature catalysis

Efficient hydrogen production and carbon capture are essential for effective green transition of energy intensive industries. Hydrogen productions on conventional heterogeneous catalysts operate at high temperatures and consume fossil energy and feedstocks. Carbon scrubbing processes generate large amounts of degraded solvent and high temperature sorbent regeneration. Enzymatic processes are underway in chemical engineering schemes where their conversion and sorption kinetics span orders of magnitudes higher over conventional catalysts. The topic will focus on assessing the opportunities in low temperature processes and optimisation of enzyme activity, recovery, and longevity. Through the design of conductive and/or magnetic-responsive carriers multiphase reactions involving water gas shift and carbon dioxide absorption processes will be examined. Electromagnetic responsive features will be investigated and finely tuned for affecting redox reactions and heat transfer. Supramolecular carriers will be designed to give rise to structure-function aimed at achieving novel host-guest relationships. Conventional heterogeneous catalysts and sorbents will be compared to enzymatic production of hydrogen and carbonate. Ultimately, enzymatic processes will be studied at controlled operating temperatures, enabling near-ambient to near-boiling point liquid-gas and gas-liquid conversion.

TOPIC 7

Controlled conductive catalysts for simultaneous hydrogen production and wastewater treatment

Water splitting is an efficient, clean, and promising alternative technology for hydrogen production. Combined with direct harnessing of light or renewable electricity, green hydrogen can be produced through photocatalytic and electrolytic processes. Heterogeneous catalysts will be utilised in advanced oxidation of wastewaters to generate oxidizing agents for degrading organic pollutants. Controlled conductive properties will be achieved, examined, described, and modelled to suit hydrolysis either through electrolysis or photocatalysis. Electrolysis and photocatalysis approaches will be compared in terms of hydraulic retention time and variations in wastewater strength. With different combinations of organic and microbial loads, various polluted water sources will be considered: i.e. low organic loads exhibiting microbial blooms (e.g. groundwater reservoirs), effluents rich in low molecular weight carbohydrates (e.g. brewery wastewaters) and effluents rich in high molecular weight carbohydrates (e.g. pulp and paper industry). Ultimately, selected wastewaters will be used in the process and examined for hydrogen evolution, organic load reduction, microbial deactivation, and biofilm disintegration.

SUPERVISOR

Dr. Janvit TERŽAN

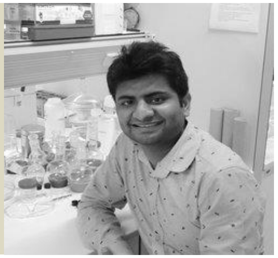
More information

TOPIC 8

Magnetic field steam reforming of biogas and methanol production

Hydrogen and synthesis gas are typically produced from hydrocarbons derived from fossil sources. Biogas steam reforming offers an efficient way of deriving synthesis gas from renewables, and methanol production a more stable and reliable way of storing syngas in a liquid form. Still, these processes are energy intensive. In these applications, magnetic field heating offers (i) operation of catalytic processes on dynamic supply from renewable energy with (ii) immediately achieving and maintaining precise operating temperatures for a wide range of temperature regimes. A wide range of heterogeneous catalysts will be scanned for magnetic heating (with/without addition of heating material and in inert/reactive conditions). Conditions and processes will be run and maintained within low (100-300 °C) and high (500-900 °C) temperature windows. Feed variation will be attempted, in terms of changing the feed composition (H20, CO2, CH4, H2, CO) and feed flow rate, to examine dynamic operation for achieving/maintaining operation temperatures, pressures and conversions.
Opportunities for hydrogel-based support precursors and/or hydrogel-based catalyst synthesis/preparation will also be examined.

SUPERVISOR



Vaibhav BUDHIRAJA

More information

TOPIC 9

Effect of microplastic on human health

The plastic particles that degrade into the environment and are intentionally added to personal care products, with a size of less than 1 mm, are called microplastics (MPs). MPs can enter the human body from the environment and through food. The extent of MP bioaccumulation and its effects on the human body are not well understood. The objective of this study is to investigate the sources, pathways and levels of human exposure to MPs. Selective artificially weathered MPs, such as Polyethylene and Polypropylene, which mimic naturally occurring MPs found in the environment will be studied. This research helps to enhance the understanding of the risks MPs pose to human health.

SUPERVISOR

Assoc. Prof. dr. Mojca BENČINA

More information

TOPIC 10

Advancing Technology Development for Rare Disease Therapy (in scope of CTGCT)

This project pioneers innovative approaches to tackle rare diseases arising from single gene mutations, a field often overshadowed in mainstream medical research. These conditions affect many globally, leaving patients with limited treatment options. Single gene mutations pose unique challenges due to their specificity and variability, prompting the need for tailored solutions. Our strategy harnesses cutting-edge technologies such as gene editing, RNA interference (RNAi), and personalized medicine to target the underlying genetic defects responsible for these diseases. By precisely correcting or modulating single gene mutations, our aim is to develop highly effective, targeted therapies with minimal off-target effects.

Key aspects of our project include:

Gene Editing Platforms: We develop advanced tools like CRISPR-Cas9, TALENs, or base editing technologies tailored to address specific single gene mutations. Our focus lies in optimizing delivery methods to ensure accurate editing within affected cells.

RNA Interference (RNAi): Utilizing RNAi-based approaches to selectively silence or modulate the expression of mutated genes, thereby slowing disease progression. We design innovative RNAi delivery systems for effective targeting and prolonged therapeutic effects. Regulatory Compliance and Clinical Translation: We adhere to rigorous regulatory guidelines throughout development, ensuring the safety and efficacy of therapeutic interventions. Collaborating closely with regulatory agencies expedites the translation of experimental therapies into clinical trials.

This initiative targets rare diseases exemplified by CTNNB1, Kleefstra Syndrome, and SATB2 disorders, each representing distinct genetic aberrations with unique therapeutic hurdles. CTNNB1 mutations disrupt the Wnt signaling pathway, while EHMT1 mutations, causing Kleefstra Syndrome, disrupt chromatin remodeling processes. SATB2 gene mutations impair proper neuronal development and function.

In addition to targeted interventions, our project emphasizes:

Advanced Disease Modeling: Utilizing state-of-the-art cellular and animal models to replicate disease phenotypes and assess therapeutic efficacy.

Translational Research: Streamlining the transition of promising therapeutic candidates from lab bench to patient bedside through rigorous preclinical studies and regulatory compliance.

Collaborative Networks: Cultivating partnerships with patient advocacy groups, academic institutions, and industry stakeholders to accelerate therapeutic development.

SUPERVISOR

Assoc. Prof. dr. Nejc HODNIK
ERC Starting Grant Holder

More information

TOPIC 11

Advanced electrochemical testing of electrocatalysts

Development and optimization of electrocatalysis for efficient conversion of electricity coming from renewable sources like the sun into chemical products (and vice versa) is of paramount importance both in academia and industry. To achieve this, a comprehensive approach integrating various advanced electrochemical characterization techniques is essential. These techniques enable high-throughput screening of catalysts, real-time monitoring of catalyst activity and stability, online dissolution analysis, and imaging at the nanoscale using electron microscopy. Integration of these methods offers profound insights into the structure-function relationships of electrocatalysts, facilitating the optimization of synthesis processes.

TOPIC 12

Electrochemical Recycling Precious (Noble) Metals from End-of-Life Products

Platinum group metals (PGMs), designated as critical raw materials due to their economic significance, are vulnerable to supply disruptions and environmentally impactful extraction methods. Recycling these metals, including iridium, is pivotal for sustainability in modern industry and energy sectors. However, PGM-leaching techniques are costly and involve hazardous processes, such as using boiling aqua regia. The development of environmentally friendly hydrometallurgical methods for dissolving and extracting PGMs like iridium holds immense value, particularly for the green hydrogen production sector. Electrochemistry (electrocatalysis) and corrosion expertise are crucial for discovering such processes through experimental approaches.

SUPERVISOR

Prof. dr. Albin PINTAR

More information

TOPIC 13

Advanced plasmonic photocatalysts for sustainable chemical processes

Heterogeneous photo(thermo)catalysis using visible light or near-infrared radiation is an attractive way to carry out a variety of chemical reactions (e.g. oxidation of organic pollutants dissolved in water, reduction of pollutants in the air, water splitting, CO2 reduction, etc.) in a sustainable way. To this end, advanced photocatalysts need to be developed that allow efficient use of (sun)light via localized surface plasmon resonance effects. Within this topic, nano-shaped photocatalysts based on noble and/or transition metals will be synthesized and characterized using various instrumental techniques to investigate the textural, surface, optical and electronic properties of the materials. For example, solid-state EPR and time-resolved photoluminescence analysis - both techniques at our disposal - will be an important part of these activities. Whenever possible, spectroscopic techniques will be used for in situ and operando characterization of synthesized photocatalysts. For catalyst development and experimental verification, modeling will be performed using the discrete dipole approximation method. The synthesized plasmonic solids will be investigated in selected model reactions to derive quantitative structure-activity and structure-selectivity relationships (QSAR). The experiments will be carried out in batch as well as flow-through two- and three-phase reactors, preferably operated at ambient temperature and atmospheric pressure. For the latter, perspective photocatalysts in the form of powders will be immobilized on structured microreactors as thin films and their long-term performance (activity, selectivity, lifetime) will be investigated in detail. It is expected that the results of this perspective research work will be published in high-ranking journals and presented at several international scientific conferences.

SUPERVISOR

Dr. Alen ALBREHT

More information

TOPIC 14

Structural and functional studies of proteins involved in pathogenesis of intracellular bacteria

As powerful antioxidants, xanthophylls are key to maintaining healthy vision, but they also help combat metabolic disorders, cardiovascular diseases, cancer, and they also have positive effects on cognitive performance. In the frame of this project, we aim to design a new line of nutraceuticals, mainly xanthophylls, with enhanced physicochemical properties such as chemical stability and/or water solubility, for instance. Renewable plant materials (invasive alien plant species, inedible parts of fruits and vegetables, etc.) will be screened for and used as a primary source of these compounds, which will be subjected to different modifications to produce potential value-added products. Modified bioactives will be scrutinized to establish their new physicochemical properties, bioactivity (e.g. antioxidant activity), bioaccessibility, and as new compounds, they will also be assessed for their potential toxicity. Their enhanced properties will be mapped to their governing chemical mechanisms that will allow a rational design of future health-promoting nutraceuticals. Research will be conducted by considering many research approaches such as: (i) chromatographic (e.g., (U)HPLC, GC, TLC), spectroscopic (e.g., spectrophotometry, HRMS), and hyphenated analytical techniques (e.g., HPLC-UV-MS); (ii) design of experiments in combination with modern extraction techniques (sc-CO_2 extraction, accelerated solvent extraction, and ultrasound-assisted extraction); (iii) basic synthetic approaches (e.g., esterification, methylation, peptide synthesis); (iv) molecular biology (cell experiments); and (v) green chemistry and sustainability will also be a major aspect of the project.

With the rapid growth of human population, the quality and safety of food have become vital. By taking an interdisciplinary approach, this topic introduces the rational design of future nutraceuticals which could be tailored to meet specific societal needs. The fabrication and comprehensive characterization of model xanthophylls will create new knowledge, feeding a systematic database of key structure-property relationships. By respecting the 12 basic principles of green chemistry, the developed technologies will support a sustainable implementation of results.

SUPERVISOR

Dr. Angelja Kjara SURCA

More information

TOPIC 15

Electrocatalysts through the eyes of Raman and UV-visible spectroscopy

In the hydrogen cycle, a Proton Exchange Membrane Water Electrolyzer (PEMWE) converts excess of electrical energy from renewable energy sources into hydrogen and oxygen, which can be later recombined in a Polymer Electrolyte Membrane Fuel Cell (PEMFC) to produce electricity when needed. For this purpose, various electrocatalysts (based on Ir, Ru, Pt, Ni, Ni/Fe, Co …) and appropriate supports (TiNx, carbon black …) for them are needed and studied. In addition to the usual electrochemical and characterization (TEM, SEM, XRD …) techniques used, we suggest the investigation of electrocatalysts using Raman spectroscopy and UV-visible absorbance spectroscopy. These techniques can provide valuable insights into the behaviour of different electrocatalysts and can be adapted to in-operando measurements. Electrocatalyst samples will also be prepared in the form of thin films, either using electrodeposition or other wet-chemical techniques, such as the sol-gel route. The films are particularly needed for in-situ UV-visible absorbance spectroscopy, but can be used also for Raman spectroscopy. The investigation of some electrocatalysts requires the use of surface enhanced Raman spectroscopy (SERS), which also implies the preparation of a rough Au substrate for measurements. For your study, it is possible to choose among several different electrocatalysts.

SUPERVISOR

Dr. Ana KROFLIČ

More information

TOPIC 16

Changing atmosphere: aerosol aging in mixed natural and anthropogenic emissions

In the hydrogen cycle, a Proton Exchange Membrane Water Electrolyzer (PEMWE) converts excess of electrical energy from renewable energy sources into hydrogen and oxygen, which can be later recombined in a Polymer Electrolyte Membrane Fuel Cell (PEMFC) to produce electricity when needed. For this purpose, various electrocatalysts (based on Ir, Ru, Pt, Ni, Ni/Fe, Co …) and appropriate supports (TiNx, carbon black …) for them are needed and studied. In addition to the usual electrochemical and characterization (TEM, SEM, XRD …) techniques used, we suggest the investigation of electrocatalysts using Raman spectroscopy and UV-visible absorbance spectroscopy. These techniques can provide valuable insights into the behaviour of different electrocatalysts and can be adapted to in-operando measurements. Electrocatalyst samples will also be prepared in the form of thin films, either using electrodeposition or other wet-chemical techniques, such as the sol-gel route. The films are particularly needed for in-situ UV-visible absorbance spectroscopy, but can be used also for Raman spectroscopy. The investigation of some electrocatalysts requires the use of surface enhanced Raman spectroscopy (SERS), which also implies the preparation of a rough Au substrate for measurements. For your study, it is possible to choose among several different electrocatalysts.

SUPERVISOR

Prof. dr. Simona GOLIČ GRDADOLNIK

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TOPIC 17

Dynamic aspect of ligand-protein binding

A variety of processes essential to living organisms involve ligand-protein binding, in which the ligands switch proteins between different functional states. The atomically resolved structures of ligand-protein complexes form the basis for understanding ligand-protein interactions. However, it is becoming increasingly clear that dynamic processes play an important role in the mechanism of ligand-protein binding. Therefore, a combined structural and dynamic characterization of ligand-protein binding is required for a comprehensive understanding of its mechanism and functional role in a given life process.

The aim of our studies is the site-specific characterization of dynamic processes in ligand-protein complexes on a wide time scale at atomic level using a combined approach of high-field nuclear magnetic resonance spectroscopy (NMR), infrared spectroscopy and molecular dynamics simulations. The state-of-the-art high-field NMR spectrometers (800 and three 600 MHz), spectrometers for linear, Raman and two-dimensional femtosecond infrared studies as well as powerful computer clusters are available in-house. We investigate binding of inhibitors, endogenous modulators and lipids to various proteins. Research consists of detailed characterization of protein dynamics in ligand-protein complexes, including the involvement of low-populated protein high-energy states, which are also important for protein binding and function in health and disease. Attention is also focused on the characterization of coupled ligand-protein motions and on a still very poorly understood relationship between the intrinsic flexibility of the ligand and its biological efficacy. Our recent results have shown that these dynamic processes strongly influence the ligand-protein interactions in addition to the intrinsic protein motions and can be linked to the functional activities of the ligand.

The results of the studies can significantly contribute to the progress of molecular medicine and are of great interest for many specific research areas, such as molecular recognition, molecular signaling, enzyme catalysis, protein folding, target-based design and discovery of drugs.

SUPERVISOR

Yufei MA

More information

TOPIC 18

Enhancing Oxygen Evolution Activity and Stability: Interfacial Engineering of Spinel Oxides for Balanced LOM and AEM Mechanisms

In electrochemical water splitting, the oxygen evolution reaction (OER) is slower than the hydrogen evolution reaction (HER) due to its complex four-electron–proton-transfer process. Metal oxides (i.e. spinel oxides) typically enable OER via four proton–electron transfer steps, limited by the thermodynamic relationship between OH* and OOH* energies. A new OER pathway, the lattice oxygen oxidation mechanism (LOM), has been introduced, utilizing catalyst lattice oxygen for O–O bond formation, potentially overcoming these limitations. The LOM mechanism involves the participation of lattice O in the reaction, with the O vacancies created being refilled by OH- from the solution. Generally, the rate of lattice oxygen evolution is much faster than the refilling rate, leading to surface reconstruction, thereby affecting the catalyst's performance. This surface reconstruction hides metal oxides' true active sites, complicating the study of OER mechanisms. Spinel oxides, with their excellent conductivity and abundant active sites, have gained attention as OER catalysts. Doping with metal or non-metal elements can adjust the M-O bond and orbital hybridization, inducing the LOM mechanism. This project proposes constructing interfaces of various spinel oxides to balance LOM and AEM mechanisms. By doping metal and non-metal elements to stimulate the LOM mechanism of a type of spinel oxide and combining it with the surface undergoing the AEM mechanism of spinel oxides, at the interface of the two types of spinel oxides, the active oxygen species (O-O) generated by the AEM mechanism can quickly fill the lattice oxygen vacancies produced by the LOM mechanism. By regulating the type and concentration of doping elements, the balance between the reaction rates of AEM and LOM was optimized, a high-activity, high-stability intrinsic catalytic reaction interface can be achieved when the rate of active oxygen species generation (AEM) matches the oxygen vacancy filling rate (LOM).

SUPERVISOR

Dr. Primož JOVANOVIČ

More infromation

TOPIC 19

Guiding Principles for Hydrogen Oxidation Reaction in Non-aqueous Electrolytes

In electrocatalysis most efforts have been targeted at investigating electrochemical reactions in conventional aqueous-based environments. From fundamental point of view, knowledge on non-aqueous (non-AQ) electrochemistry is scarce. Focusing on electrocatalytic aspects in non-AQ electrolytes is a necessary step beyond the established practice in the field of electrocatalysis. In this context the hydrogen oxidation reaction (HOR), even though perhaps the most studied of all electrocatalytic reactions, is utterly unexplored in non-AQ electrolytes. Notably, this particular platform will become of pivotal importance in the sector of energy conversion motivated by rapidly evolving topic of electro-synthesis, in particular ammonia (NH3) production via electrochemical reduction of nitrogen (NRR). In this context pairing NRR with HOR would avoid a sacrificial solvent as a proton source and could also lower the cell voltage to improve NH3 selectivity and energy efficiency. The core of proposed research is an advanced investigation of non-AQ HOR proceeding where the candidate will take HOR research in a novel direction by executing radically different approaches for studying the HOR. Experimental strategy proposed herein will constitute of HOR investigation under elevated mass transport of H2. Accordingly, he/she will develop floating electrode configuration. The electrode setup will be coupled with mass spectrometry and infrared spectroscopy analytics. Hyphenated diagnostic will allow HOR proceeding under elevated mass transport, in-situ and real-time resolved observation of the operating electrocatalyst. This will assure abundant harvest of experimental insights in a time non-consuming manner on the basis of which he/she will deliver guiding principles for catalyst design. The cutting-edge equipment at National Institute of Chemistry (NIC) and principal investigator's strong connections to world-renowned experts ensures the perfect environment to successfully host project despite its challenging nature.

SUPERVISOR

Dr. Francisco RUIZ ZEPEDA

More infromation

TOPIC 20

Electron microscopy for the study of stability in catalysts

By combining electron microscopy advanced analytical techniques, such as identical location and 4D-STEM, we try to provide insights into catalytic degradation processes.
Since understanding the underlying mechanisms of catalyst stability can guide the development of more durable catalyst materials.

SUPERVISOR

Prof. dr. Samo HOČEVAR

More information

TOPIC 21

Development of sensitive and selective electrochemical biosensors for the point-of-care application

The research will focus on the development of sensitive and selective electrochemical biosensors for the point-of-care detection of important biological analytes such as viruses, viroids, antigens, antibodies, DNAs/RNAs, biomarkers, etc. The studies will include the preparation, selection, and pretreatment of suitable supporting electrodes, modification of supporting electrodes with various inorganic and organic (bio)materials to facilitate the binding of the biorecognition elements, to exploit the electrocatalytic properties of selected materials, to immobilize the building blocks of the biosensor, all aimed at increasing sensor's sensitivity and selectivity. The investigation will tackle the development and selection of appropriate biosensing schemes and their integration into the electrode system, optimization of electrochemical methodologies to achieve improved sensing performance, and testing of biosensors in simulated or real samples. The candidate will gain theoretical and practical insights into electrochemical techniques, such as amperometry, (stripping)voltammetry, potentiometry, and electrochemical impedance spectroscopy. Numerous electrode materials will be examined, such as carbon-based materials (glassy carbon, carbon paste, carbon fiber, screen-printed carbon), bismuth, gold, and platinum, as well as advanced electrocatalytic materials, etc. Different electrode modification strategies will be employed such as drop-casting, dip-coating, spin-coating, as well as chemical and electrochemical approaches. The fabricated sensor surfaces will be analyzed using laser ablation hyphenated with inductively coupled plasma elemental mass spectrometry, atomic force microscopy, scanning electron microscopy, interferometry, electrochemistry, spectroscopy, etc. The candidate will acquire specific knowledge in handling biological samples and reagents, microvolume samples, and trace analysis.

SUPERVISOR

Dr. Kristijan VIDOVIĆ

More information

TOPIC 22

Atmospheric Chemistry Processes Influencing Climate

Different atmospheric processes can influence the climate either directly or indirectly. Directly, they impact the climate by forming absorbing or light-scattering species, which can contribute to the overall radiative balance of the Earth. Additionally, various atmospheric processes can induce particle formation, which, in turn, can act as cloud condensation nuclei, contributing to cloud formation and indirectly affecting the climate by cooling the atmosphere. Moreover, it is known that atmospheric particles introduce the highest uncertainty in predicting Earth's climate. Therefore, their formation and degradation within different atmospheric processes are very important.

Understanding the formation of light-absorbing and light-scattering particles is of crucial interest to the atmospheric science community. Brown carbon, as one of the most absorbing groups of organic compounds, plays a unique role due to its dynamic formation and degradation in the atmosphere. The chemical mechanisms of its formation play a crucial role in understanding the impact of atmospheric particles on climate. However, it's not only the chemical formation of brown carbon compounds that is important, but also their ability to form particles or contribute to particle growth.

To understand the formation of various brown carbon compounds from relevant atmospheric precursors and their influence on particle dynamics, the candidate will be introduced to state-of-the-art analytical instrumentation including GC-MS, LC-MS/MS, ICP-MS, IC, and UV/vis spectroscopy. Furthermore, to investigate the influence of these compounds on particle dynamics, the candidate will utilize scanning particle mobility sizer. In conclusion, to estimate the absorption properties of such formed brown carbon particles, the candidate will employ the Aethalometer.

SUPERVISOR

Dr. Vasko JOVANOVSKI

More information

TOPIC 23

Electrochemical gas sensors

Gas sensing has gathered significant attention due to its relevance in various emerging fields such as clinical diagnostics, homeland security, and occupational and environmental safety. To monitor elevated levels of specific gases, various measurement techniques have been explored extensively. Among these, gas sensors exploiting chemiresistivity and optoelectronic phenomena are predominantly researched due to their potential for portability and accurate measurements. However, chemiresistive sensors based on inorganic materials often require elevated temperatures and are sensitive to humidity, limiting their broader applications. Electrochemical gas sensors are also gaining traction owing to their cost-effectiveness and tunability for selective and sensitive measurements of one or more analytes under ambient conditions. When coupled with modern electronics, they can be significantly miniaturized to achieve portability and therefore on-site measurements. While electrochemical methods have traditionally been employed for liquid-phase measurements, they can be adapted for gas-phase analyte detection while retaining favourable characteristics such as sensitivity, low cost, and operation at room temperature. A novel electrochemical gas sensing platform has recently been developed, featuring a multi-task semi-solid electrolyte layer that fulfils several key requirements. This includes facilitating the solubility of gaseous analytes for improved sensitivity, enabling chemical transformation of analyte molecules when necessary to achieve or improve electrochemical activity, and providing electrolyte media that promote high diffusion rates of target molecules to the electrode surface for rapid detection. Currently, our research has successfully developed gas sensors for detecting formaldehyde and phenol, with ongoing efforts focused on sensing hydrogen peroxide and peroxo explosive vapours.

SUPERVISOR

Dr. Luka SUHADOLNIK

More information

TOPIC 24

High-entropy materials for electrocatalytic applications

The objective is to produce new, cost-effective and high-performance (active and stable) electrocatalysts. The materials of focus are high-entropy materials (HEMs) that will be prepared from high-entropy alloys (HEAs) with various electrochemical and other processes. Starting HEAs will be prepared in bulk form and post-treated to synthesise high-entropy materials in the form of high-surface-area nanostructured films on HEA substrates. All HEMs will be fully characterized in terms of stability, structure and morphology. Finally, they will be tested for electrocatalytic properties with state-of-the-art characterization techniques.

NEXT STEPS

NIC CALL CLOSING DATE: June 28, 2024

To apply, applicants must select one of the “Supervisors project proposals” and indicate their interest in applying with NIC by sending the following four forms to project.office@ki.si with the **subject:** MSCA-PF-2024-Application

1. Curriculum vitae and publications list
2. Letter of motivation and research statement (provided template)
3. Eligibility self-declaration (provided template)
4. Certificate of proficiency in the English language

All forms are mandatory. Applications missing any of the documents will not be considered.

Selected applicants will receive support from the Project Management Office during the application process and will be invited to a webinar in which the further procedure will be explained.

Fluency in English is required. Knowledge of Slovenian is not required.

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