



Topics for the Janko Jamnik Doctoral Scholarship for Promising Early-Stage Researchers in Chemistry and Related Sciences for 2021

Topic Title	Short Content	Mentor	Department
The origin of entropy	In environmentally important reactions in the atmosphere, entropy plays a decisive role. Thermodynamics of reactions in atmospheric aerosols, which are important environmental pollutants, will be studied theoretically (quantum molecular dynamics, statistical thermodynamics) and experimentally (photolysis with laser beam).	Matej Huš	D13/D04D/01
Catalyst screening with modelling	Modelling of chemical reactions and reactors has made tremendous progress in the past decade and enables the predictions of reaction mechanisms. Using this approach, we will computationally screen the periodic system and predict a better catalyst for nitrogen activation and experimentally test it.	Matej Huš	D13/D09
Photo-thermo-catalytic (de)hydrogenation of organic hydrogen carriers	The storage of hydrogen produced remains one of the key challenges for decarbonising economy.	Blaž Likozar	D13/D9
Multi-scale process design of direct air capture (DAC) of CO ₂	Capturing CO ₂ from the air allows the use of a carbon source that will be available even after the decarbonisation of industrial economy.	Blaž Likozar	D13/D9
Multi-scale description of electro-catalytic production of various consumer chemicals	The electrification of conventional chemical production processes needs to solve the challenges of separating the compounds from electrolytes, etc.	Blaž Likozar	D13/D10



Topic Title	Short Content	Mentor	Department
Modulating CAR-T cell cancer immunotherapy	CAR-T cell immunotherapy represent a revolutionizing highly efficient therapeutic option for treating various cancer, including lymphomas and leukemia. CAR-T cell immunotherapy is based on autologous transplantation of genetically modified cells, which kill cancer cells upon reinfusion into patient's body. We plan to implement versatile approaches of synthetic biology (signal and its pathway modification CRISPR/Cas usage etc.) in CAR-T cell immunotherapy for different cancers. With CAR-T cell modulation we want to make this therapeutic option more safe and controllable. Doctoral research will include various techniques, from confocal microscopy, cloning to testing de novo designed CAR-T cells in animal models.	Duško Lainšček	D12/D11
Catalytic Upgrading of Selected C2–C6 Platform Chemicals Derived from Biomass in a Packed-Bed Continuous Flow and/or Batch Reactors	In contrast with fossil resources, renewable biomass is a virtually inexhaustible reservoir of chemical building blocks with an estimated global production of 1.7×10^{11} tons per year. Europe and the US have launched ambitious programs over the next decades to support the development of dedicated bio-based economy, where the EU aims at a reduction of 40% of greenhouse gas and at an overall 25% biobased chemicals and materials by 2030.	Andrii Kostyniuk	D13/D09



Topic Title	Short Content	Mentor	Department
Organic Electrosynthesis	Research will explore the use of electrochemical techniques to synthesize organic compounds. Oxidation and reduction agents are commonly needed to drive organic synthesis, but this investigation hopes to circumvent these potentially costly and wasteful reagents by using electrochemistry to selectively add or remove electrons in organic reactions. This work will be used to develop new organic synthesis pathways or to scale up reactions in a sustainable and environmentally friendly manner.	Primož Jovanovič	D10/D10/D04
Development of advanced methods in electrocatalysis	The diversity of materials and processes together with the growing amount of data require new approaches for the characterization of electrocatalysts. By combining advanced experimental methods, computer simulations and artificial intelligence methods, we will find new ways to evaluate the properties of electrocatalysts.	Nejc Hodnik	D10/D13
Sources of air pollution: PM and brown carbon	Airborne particles (PM) are our biggest environmental concern. Brown carbon influences absorption properties of the atmosphere and affects visibility, the ecosystem and climate change. PhD will focus on mechanisms of atmospheric brown carbon formation and aging, which will be through kinetic consideration of relevant reactions in model reactor systems.	Ana Kroflič	D04/D13



Topic Title	Short Content	Mentor	Department
Microplastics in the atmosphere	Our planet is covered with (micro)plastics. It is well known that we can find it in oceans, far away from its pollution sources – but do we also breathe it? Due to the specifics of its entering the body, it is extremely challenging to detect airborne microplastics that is harmful to our health. In focus of this PhD will be the development of new methodology to determine micrometer-size microplastics in ambient air.	Ana Kroflič	D04/D10/D13
Impact of RNA 2'-O-methylation on the binding specificity and affinity of Staufen proteins	Staufen proteins are double-stranded RNA-binding proteins that regulate mRNA decay, localization and translation in mammalian cells, and their defects are associated with neurodegenerative disease. In vitro transcribed 2'-O-methylated oligonucleotides will be prepared and characterized by mass spectrometry, followed by differential measurements of Staufen binding affinity towards non-methylated and methylated RNA substrates (EMSA, anisotropy, ITC).	Ana Kroflič	D04/D11
Synthesis of amphiphilic block copolymers of various architectures for the preparation of polymersomes	The candidate will prepare bioinspired amphiphilic block copolymers capable of forming stable polymer vesicles (polymersomes) suitable for reconstitution of pore-forming proteins. By altering the architecture of block copolymers we aim to reduce the membrane thickness to facilitate the reconstitution of biopores without compromising membrane stability.	David Pahovnik	D07/D11



Topic Title	Short Content	Mentor	Department
Engineering of catalytic processes for bio-refineries	Development and optimisation (D10) and processes for efficient conversion of biomass into value-added chemicals (D13) are crucial in the design of bio-refineries, which are expected to be established in Slovenia in the near future.	Miha Grilc	D13/D10
Advanced electrochemical durability studies of hydrogen fuel cell catalysts	Fuel cells are devices that convert hydrogen and oxygen into clean electricity. To do that efficiently over a long period of time, they require a durable catalyst. To understand and study the complex degradation phenomena, the use of advanced characterization methods is required.	Matija Gatalo	D10/D04
Reactor engineering and production of advanced hydrogen fuel cell catalysts	Catalyst represents the heart of every fuel cell and enables conversion of hydrogen and oxygen into clean electricity and water as the only by-product. To enable a more rapid and sustainable ramp-up of fuel cell technology, it thus all start with making of a better, a more durable and a more affordable catalyst.	Matija Gatalo	D10/D13
Greenhouse gas adsorption in nanoporous composites	Some metal-organic frameworks (MOFs) can adsorb large amounts of greenhouse gases and thus have great industrial potential to reduce the carbon footprint. Limitations of MOFs will be addressed by the preparation of hybrid materials, i.e. incorporation of MOFs into macroporous organic scaffolds. For studies of the interactions between the organic matrices and the embedded MOFs, and for studies of gas binding sites inside the hybrids, advanced solid-state nuclear magnetic resonance methods will be developed and employed.	Andraž Krajnc	D09/D07



Topic Title	Short Content	Mentor	Department
Selectivity Control In Catalytic Transformation of C1 Molecules (CO/CO2 Hydrogenation) Into C2+ Products	Syngas (a mixture of hydrogen and carbon monoxide) chemistry has become increasingly important because of the increasing interest in the utilization of non-petroleum carbon resources to replace diminishing resources of crude oil for sustainable production of liquid fuels and chemicals. From syngas over bifunctional catalysts in one-step conversion, a variety of products such as hydrocarbons, which can be fuels (gasoline, diesel fuel, and jet fuel) or chemicals (olefins and aromatics), and oxygenates (methanol and C2+ oxygenates) can be obtained.	Andrii Kostyniuk	D13/D09
Gas Phase Glycerol Valorization over Heterogeneous Catalysts Into High Value-Added Chemicals Under Ambient Pressure in a Packed-Bed Reactor	Glycerol is a byproduct in biodiesel production representing roughly 10% of the mass of the biodiesel produced, which led to a decrease of the glycerol commercial price due to its high abundance on the world market. Glycerol valorization can be carried out in the gas-phase over heterogeneous catalysts. The most interesting products of this process are: acrolein, acrylic acid, dihydroxyacetone, hydroxyacetone, allyl alcohol, epichlorohydrin, lactic acid, 1,2-propanediol, 1,3-propanediol, and very recently ethanol. These products are attractive for commercialization due to many applications and competitive price on the world market.	Andrii Kostyniuk	D13/D09



Topic Title	Short Content	Mentor	Department
Development of analytics for the determination of bilirubin and biliverdin	Bilirubin and biliverdin are catabolic breakdown products of heme, but are thought to play an important mediator role in the human body in responding to cellular oxidative stress. To this end, we will develop an analytical platform for the accurate evaluation of free bilirubin, biliverdin and their oxidation products within different biological matrices (serum, saliva, etc.). With the help of theoretical computational approaches, we will determine some as yet undefined physicochemical properties of these compounds.	Alen Albreht	D04/D01
Development of biologically active and chemically stable xanthophylls	Supplementation with xanthophylls is currently the only effective measure to prevent macular degeneration, which affects more than 67 million people in the EU alone. Based on esterification, we will develop new xanthophylls, which we will characterize using separation and spectroscopic techniques, computational approaches, as well as <i>in vitro</i> tests. The results will be the basis for the development of new dietary supplements with biologically active and chemically more stable xanthophylls.	Alen Albreht	D04/D01



Topic Title	Short Content	Mentor	Department
Insects as a food source	The European Food Safety Authority first approved the use of certain insects in human nutrition in 2021, as they represent a sustainable rich source of protein, fat and fiber and do not cause greenhouse gases in contrast to livestock farming. We will study biologically active compounds in various insects that have a positive effect on human health and are relatively unexplored, and we will study how we can change their composition and content in insects.	Alen Albreht	D04/D013
Understanding and advanced upgrading of natural nanofibers and nanomaterials to achieve new state-of-the-art functionalities in the sustainable (bio) materials of the future.	By understanding natural systems, we will discover, through biomimicry, the importance of using fiber structures to achieve the new most advanced functionalities in the sustainable (bio) materials of the future. The focus will be on the architecture of natural isolated fibers, and bionanomaterials that will be embedded in biopolymer matrices, with the aim of studying the release of small molecules or even changing the shape that mimics the opening and closing of flowers (4D) materials. In addition, opportunities for innovation will be reviewed, leading to further research and the development of multi-layered and stimulus-responsive intelligent solutions, with applications in the circular interplanetary bioeconomy.	Uroš Novak	D13/D10



Topic Title	Short Content	Mentor	Department
Valorisation of lignin into the targeted aromatics	Lignin is one of the main components in lignocellulosic biomass and represents the only sustainable source for various monoaromatics as well as aromatic building-blocks for production of bio-based polymers. Quantitative NMR evaluation of the various functional groups and structural features in lignin is crucial for the development of the tailored isolation and fractionation methodology. The targeted aromatics are produced as a result of the efficient combination of tailored biopolymer isolation, fractionation and catalytic depolymerisation.	Edita Jasiukaityte Grojzdek	D13/D15
Dynamic ensembles of nucleic acids and their role in cellular processes	3D structure of macromolecules lacks information on key aspects of macromolecular function and activity. We will focus on how detailed description of nucleic acids dynamics can be used to quantitatively predict their molecular behaviour and explain characteristics of cellular processes in which they are involved.	Maja Marušič	D15/D12/D11