



**80<sup>th</sup> International Scientific  
Conference of the  
University of Latvia 2022**

# **CHEMISTRY SECTION**

## **BOOK OF ABSTRACTS**



**UNIVERSITY  
OF LATVIA**



**80<sup>th</sup> International Scientific  
Conference of the  
University of Latvia 2022**

## **CHEMISTRY SECTION**

**BOOK OF ABSTRACTS**

80<sup>th</sup> International Scientific Conference of the University of Latvia 2022.  
*Chemistry Section. Book of Abstracts.* Riga: University of Latvia Press. 82 p.

Scientific Committee:

Agris Bērziņš, Kristaps Saršūns, Arturs Viksna, Vadims Bartkevičs, Kristīne Meile,  
Artis Kinēns, Edgars Sūna

Editors:

Assoc. Prof. Agris Bērziņš  
Prof. Edgars Sūna  
Prof. Arturs Viksna

Prepared by the University of Latvia Press

© Authors of abstracts, 2022

© University of Latvia, 2022

ISBN 978-9934-18-809-1 (PDF)

<https://doi.org/10.22364/iscul.80.cs.ba>

# CONTENTS

<b>SECTION OF ANALYTICAL CHEMISTRY</b> .....	7
THE OPPORTUNITIES AND CHALLENGES OF CHEMICAL PROFILING OF HERBAL EXTRACTS USING CHROMATOGRAPHIC ANALYSIS .....	8
<b>Ance Bārzdiņa, Artūrs Paulausks, Agnese Brangule</b>	
ISOLATION OF FOUR TOCOTRIENOL HOMOLOGUES AND PLASTOCHROMANOL-8 FROM PLANT OILS AND THE RAPID ‘GREEN’ ANALYSIS OF NINE TOCOCHROMANOLS IN COLD-PRESSED PLANT OILS VIA SUPERFICIALLY POROUS PARTICLE PACKED COLUMN TECHNOLOGY AND SUPERCRITICAL FLUID CHROMATOGRAPHY .....	10
<b>Georgijs Baškirovs, Pawel Gornas</b>	
IMPACT OF AMINO ACID CONTAINING FERTILIZER ON ELEMENTAL AND ISOTOPIC CONTENT IN SPRUCE AND PINE STANDS .....	11
<b>Maris Bertins, Lauma Busa, Dagnija Lazdina, Karlis Dumins, Signija Zake, Maris Klavins, Arturs Viksna</b>	
APPLICATION OF WASTEWATER – BASED EPIDEMIOLOGY FOR TRACKING HUMAN EXPOSURE TO DEOXYNIVALENOL AND ENNIATINS .....	13
<b>Zane Berzina, Romans Pavlenko, Laura Elina Ikkere, Vadims Bartkevics</b>	
DISCRIMINATION BETWEEN CONVENTIONALLY AND ORGANICALLY FERTILIZED GRAINS BY FTIR AND 1H NMR SPECTROSCOPY COMBINED WITH CHEMOMETRICS .....	15
<b>Lauma Buša, Karīna Taranda, Arturs Viksna, Rihards Klūga</b>	
SYNTHESIS OF IRON HEXACYANOFERRATE IMOBILISED ON CELLULOSE ACETATE FOR CAESIUM SORPTION FROM AQUATIC ENVIRONMENTS .....	16
<b>Ugis Eismonts, Maris Bertins, Kristine Saleniece, Olga Muter, Arturs Viksna, Ingars Reinholds, Andrejs Grinbergs</b>	
CHARACTERISATION OF SUBERINIC ACIDS AND THEIR POTENTIAL APPLICATIONS ....	18
<b>Daniela Godina</b>	
BIOACTIVITY ENHANCEMENT OF PEO COATINGS BY INTRODUCTION OF AMORPHOUS CALCIUM PHOSPHATE PARTICLES .....	19
<b>Vladlens Grebņevs, Şahin Altundal, Roman Viter, Mateusz Dulski, Marta Wala, Katarzyna Leśniak-Ziółkowska, Arturs Viksna, Wojciech Simka</b>	
RECENT TRENDS IN PESTICIDE ANALYSIS BY TWO-DIMENSIONAL LIQUID CHROMATOGRAPHY – MASS SPECTROMETRY .....	21
<b>Āris Jansons, Vadims Bartkevičs</b>	
DETERMINATION OF LATVIAN HONEY FLORAL ORIGINS USING IRMS, UHPLC-HRMS, ICP-MS, FT IR AND 1H-NMR .....	23
<b>Krišs Dāvids Labsvārds, Vita Rudoviča, Jānis Ruško, Rihards Klūga, Lauma Buša, Māris Bērtiņš, Ineta Eglīte, Jevgeņija Naumenko, Marina Šalajeva, Arturs Viksna</b>	
INVESTIAGTION OF NANOSTRUCTURED BI2SE3 THIN FILMS AS ANODES FOR AQUEOUS RECHARGEABLE LITHIUM-ION BATTERIES .....	25
<b>Vitālijs Lazarenko, Yelyzaveta Rublova, Raimonds Meija, Jana Andžāne, Vanda Voikiva, Arturs Viksna, Donāts Erts</b>	

TEMPERATURE EFFECT ON THE YIELD OF METHANE FROM BOG SLUDGE AND REED RAW MATERIALS .....	26
<b>Sergejs Osipovs, Aleksandrs Pučkins</b>	
SEPARATION OF BLACK ALDER BARK EXTRACTS USING SOLID PHASE EXTRACTION TO OBTAIN FRACTIONS WITH IMPROVED PROPERTIES .....	27
<b>Matiss Pals, Maris Lauberts, Jevgenija Ponomarenko, Alexandr Arshanitsa</b>	
DIETARY EXPOSURE ASSESSMENT TO PERFLUOROALKYL SUBSTANCES .....	29
<b>Elina Pasecnaja, Dzintars Zacs</b>	
QUALITATIVE FINGERPRINTING OF PSYCHOACTIVE PHARMACEUTICALS, ILLICIT DRUGS, AND RELATED HUMAN METABOLITES IN WASTEWATER DURING THE COVID-19 PANDEMIC IN RIGA, LATVIA .....	31
<b>Ingus Perkons, Laura Elina Ikkere, Veronika Sukajeva, Iveta Pugajeva</b>	
<b>SECTION OF PHYSICAL CHEMISTRY .....</b>	<b>33</b>
COST GAINS AND CO <sub>2</sub> REDUCTION IN GREENHOUSE HEATING BY AIR TO WATER HEATPUMP LATVIA DURING 2 <sup>nd</sup> HALF OF 2021 .....	34
<b>Agris Auce, Indulis Horns, Aivars Jeremuss, Ādolfs Ruciņš, Mareks Drozdovs, Ivars Auce, Uģis Grīnbergs</b>	
GRAPHENE IN LAYERED NANOSTRUCTURES .....	36
<b>Margarita Baitimirova, Jana Andzane, Roman Vīter, Mikhael Bechelany, Donats Erts</b>	
EXPERIMENTAL AND THEORETICAL STUDY OF FREE VOLUME IN SILICON-FUNCTIONALIZED IONIC LIQUIDS .....	38
<b>Eduards Bakis, Kateryna Goloviznina, Ines Vaz, Agilio Pádua, Margarida Costa Gomes</b>	
A NEW FRONTIER FOR NON-DESTRUCTIVE SPATIAL ANALYSIS OF PHARMACEUTICAL SOLID DOSAGE FORMS: MICRO-SPATIALLY/SPATIALLY OFFSET LOW-FREQUENCY RAMAN SPECTROSCOPY .....	40
<b>Kārlis Bērziņš, Sara J. Fraser-Miller, Keith C. Gordon</b>	
EXPLORING ASPARTIC PROTEASE INHIBITOR BINDING TO DESIGN SELECTIVE ANTIMALARIALS .....	42
<b>Raitis Bobrovs, Emīls Edgars Basens, Laura Drunka, Iveta Kanepe, Sofija Matisone, Karlis Kristofers Velins, Victor Andrianov, Gundars Leitis, Diana Zelencova-Gopejenko, Dace Rasina, Aigars Jirgensons and Kristaps Jaudzems</b>	
THERMAL ANALYSIS AND IR SPECTROSCOPY USAGE TO DETERMINE THE DEGREE OF SULFONATION OF SPEEK .....	44
<b>Dmitrijs Bogdanovs, Einārs Sprūģis, Guntars Vaivars</b>	
MECHANOCHEMICAL PREPARATION OF CRYSTAL FORMS OF SELECTED PHARMACEUTICAL SUBSTANCES .....	45
<b>Zane Čerpakovska, Artis Kons, Agris Bērziņš</b>	
PLASMEPSIN II LABELING STRATEGIES TO STUDY CONFORMATIONAL CHANGES OF BINDING SITE WITH NMR SPECTROSCOPY .....	47
<b>Laura Drunka, Raitis Bobrovs</b>	
VITAMIN B <sub>12</sub> BLOOD LEVEL VARIATION WITH THE AGE OF PATIENTS .....	48
<b>Didzis Gavars, Agris Auce, Eriks Tauckels, Ilze Lindenberga, Dmitrijs Perminovs, Anna Inese Tutane, Agnese Miķelsone</b>	

CYCLODEXTRIN BASED METAL ORGANIC FRAMEWORK CRYSTALLIZATION AND EVALUATION AS POTENTIAL DRUG CARRIER .....	49
<b>Kristīne Krūkle-Bērziņa, Anatolijs Mishnev, Kirills Šubins</b>	
USE OF SELECTIVE MOF FORMATION FOR SEPARATION OF $\alpha$ -, $\beta$ - AND $\gamma$ -CYCLODEXTRINS .....	50
<b>Kristīne Krūkle-Bērziņa, Kirills Šubins, Sergejs Beļakovs</b>	
MASS-SEPARATION OF <sup>43,44,47</sup> SC RADIONUCLIDES FROM IRRADIATED NATURAL TI TARGETS AT THE CERN-MEDICIS FACILITY .....	52
<b>Edgars Mamis, Elīna Pajuste, Thierry Stora, Sebastian Rothe, Eric Chevally, Charlotte Duchemin, Maija Radziņa</b>	
MIRCOCALORIMETER PERFORMANCE DETERMINATION AND STABILITY DETERMINATION OF NITROCELLULOSE-BASED SUBSTANCES AND THEIR COMPARISON WITH CHROMATOGRAPHIC RESULTS .....	53
<b>Kaspars Meijers, Pēteris Mekšs</b>	
IMPACT OF PHYSICAL PRETREATMENT ON THERMAL PROPERTIES OF COURSED SHEEP WOOL FIBERS .....	55
<b>Jānis Nesenbergs, Taisija Gricenko Līga Avotiņa, Artūrs Zariņš, Mihails Haļitovs, Gunta Ķizāne</b>	
METALLIC NANOPARTICLE DISPERSIONS FOR CONDUCTING INK PREPARATION .....	57
<b>Aleksandrs Novikovs, Boriss Poļakovs</b>	
FINE-TUNING SOLID STATE LUMINESCENCE PROPERTIES OF MOLECULAR CRYSTALS VIA SOLID SOLUTION FORMATION .....	58
<b>Kristaps Saršūns, Agris Bērziņš, Toms Reķis</b>	
CONTROL POSSIBILITIES OF 2,6-DIMETHOXYBENZOIC ACID CONFORMATIONAL POLYMORPHISM USING CRYSTALLIZATION ADDITIVES .....	60
<b>Aina Semjonova, Agris Bērziņš</b>	
X-RAY INDUCED DEFECTS IN LITHIUM ORTHOSILICATE AND LITHIUM METATITANATE CERAMICS PREPARED USING SOLID STATE SYNTHESIS METHOD .....	62
<b>Madara Tomele, Mareks Seņko, Artūrs Zariņš, Aleksejs Zolotarjovs, Larisa Baumanē, Gunta Ķizāne</b>	
APPROACH OF USING THE OPPOSITE CHIRALITY OF CROWN ETHER STATIONARY PHASES IN CHIRAL RECOGNITION OF TETRAPEPTIDE ENANTIOMERS .....	63
<b>Toms Upmanis, Helena Kažoka</b>	
IDENTIFICATION OF THE MAIN DYESTUFFS PRESENT IN BARKS OF ALDERS, BIRCH, OAK AND ASPEN .....	65
<b>Valda Valkovska, Liāna Orola</b>	
<b>SECTION OF ORGANIC CHEMISTRY .....</b>	<b>66</b>
<b>Plenary Lectures .....</b>	<b>67</b>
ELECTROCHEMICAL GENERATION OF HYPERVALENT BROMINE(III) COMPOUNDS .....	67
<b>Igors Sokolovs, Nayereh Mohebbati</b>	
SCALE-UP DEVELOPMENT OF AGGARWAL ENAL BICYCLIC INTERMEDIATE – TOWARDS MODERN MANUFACTURING OF PROSTAGLANDIN DRUGS .....	68
<b>Andrejs Pelšs</b>	

<b>Reports</b> .....	<b>69</b>
SYNTHESIS OF 2-AMINOQUINAZOLIN-4(3 <i>H</i> )-ONE BASED PLASMEPSIN INHIBITORS .....	69
<b>Emils Edgars Basens</b>	
SYNTHESIS OF BETA-ADRENERGIC RECEPTOR AGONISTS FOR THE TREATMENT OF OBESITY .....	70
<b>Māris Bazulis</b>	
COBALT-CATALYZED AMINO ACID C(sp <sup>2</sup> )-H BOND FUNCTIONALIZATION USING ORGANIC ISOCYANIDES .....	71
<b>Aleksandrs Čižikovs</b>	
A MECHANISTICAL STUDY OF LEWIS BASE CATALYZED CYANOHYDRIN SYTHESIS .....	72
<b>Artūrs Raimonds Feldmanis, Oto Filipsons</b>	
SYNTHETIC APPROACH TOWARDS ENANTIOPURE CYCLIC SULFINAMIDES .....	73
<b>Glebs Jersovs</b>	
SYNTHESIS OF PURINE-THIAZOLOPYRIMIDINE CONJUGATES .....	74
<b>Kārlis Ēriks Kriķis, Zigfrīds Kapilinskis</b>	
C-H ACTIVATION OF LUPANE TYPE TRITERPENOIDS .....	75
<b>Vladislavs Kroškins, Jevgeņija Lugiņina, Kristiāns Jankovičs</b>	
AZIDE-TETRAZOLE EQUILIBRIUM IN PYRIDO[2,3-D]PYRIMIDINES .....	76
<b>Kristaps Leškovskis</b>	
SYNTHESIS OF BICYCLIC PROLINE ANALOGUES .....	77
<b>Mērija Meiberga</b>	
DEVELOPMENT OF SYNTHESIS PATHWAYS FOR THE LIMONOID OCTAHYDRO-1 <i>H</i> -2,4-METHANOINDENE SCAFFOLD .....	78
<b>Olavs Rāciņš</b>	
THIAZOLINE CARBENE-Cu(I)-CARBAZOLIDE COMPLEXES AS LUMINESCENT TADF MATERIALS .....	79
<b>Armands Rudušs, Žanis Sisojevs, Annija Jēce</b>	
NEW SYNTHETIC APPROACH FOR THE SYNTHESIS OF SUBSTITUTED 7-ARYLPURINES .....	80
<b>Armands Sebris</b>	
COPPER(I) CATALYZED AZIDE-ALKYNE CYCLOADDITION IN IONIC LIQUIDS .....	81
<b>Dīāna Sloboda</b>	
SYNTHESIS OF 2-AMINOQUINAZOLINES AND INDAZOLES FROM 2-FORMYLPHENYLBORONIC ACIDS .....	82
<b>Vitalii Solomin</b>	

# **Section of Analytical Chemistry**



# THE OPPORTUNITIES AND CHALLENGES OF CHEMICAL PROFILING OF HERBAL EXTRACTS USING CHROMATOGRAPHIC ANALYSIS

Ance Bārzdina<sup>1,2\*</sup>, Artūrs Paulausks<sup>1,2</sup>, Agnese Brangule<sup>1,2</sup>

<sup>1</sup> Rīga Stradiņš University, Department of Pharmaceutical Chemistry, Dzirciema iela 16, Rīga, Latvia

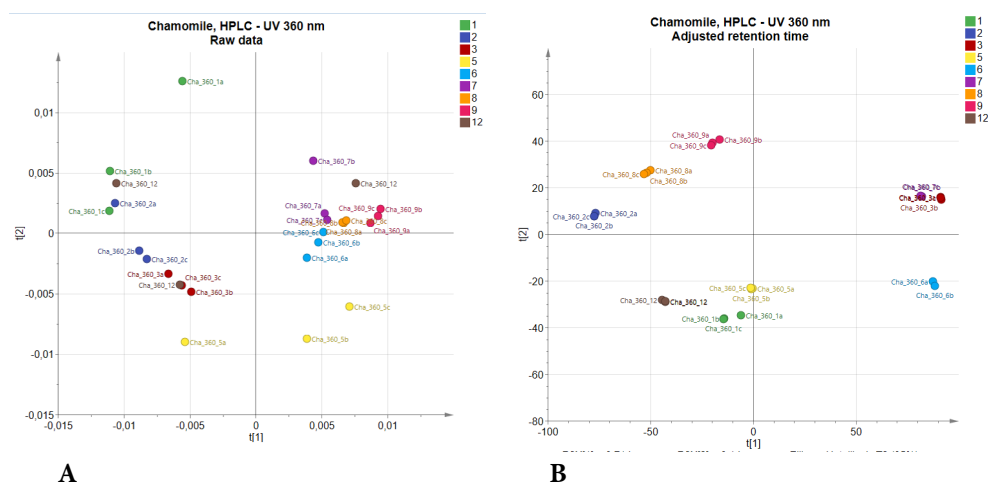
<sup>2</sup> Baltic Biomaterials Centre of Excellence, Headquarters at Riga Technical University, Kaļķu iela 1, Latvia

\* E-mail: [ance.barzdina@rsu.lv](mailto:ance.barzdina@rsu.lv)

Medicinal plants have a very complex composition with hundreds of chemical components [1]. With the ever-growing market of herbal medicines, the quality control and safety of these products have become an important issue. The currently used analytical methods provided by pharmacopeias can't provide a comprehensive chemical description of herbal medicines, so recently a chemical profiling method has gained attention [2].

The aim of this study was to determine the opportunities and challenges of chemical profiling of herbal extracts using high-performance liquid chromatography (HPLC) and thin layer chromatography (TLC). Herbal extracts were made from commercially available dried tea samples from four different medicinal plants. Multivariate and similarity analyses were performed both on raw data and data with adjusted retention times.

The main challenge that emerged with HPLC analysis was chromatographic peak shifting, which can be solved by adjusting retention times during data analysis. On average Pearson's correlation coefficient value grew by about 50% for data with adjusted retention times in comparison with raw data. Also, the quality of principal component analysis (PCA) models was significantly better for chromatograms with adjusted retention times.



**Fig. 1.** The differentiation of *Matricaria recutita* L. chromatograms. (A) The PCA clusters for raw data. (B) The PCA clusters for chromatograms with the adjusted retention time

Chemical profiling is a promising new method for the analysis of herbal extracts. Future research should be conducted with other chromatographic methods to gain a deeper knowledge of the chemical composition of herbal extracts.

## References

- [1] Goodarzi, M.; Russell, P. J., and Vander Heyden, Y. Similarity analyses of chromatographic herbal fingerprints: A review. *Analytica Chimica Acta*, **2013**.
- [2] Li, Y.; Shen, Y.; Yao, C.-L, and Guo, D.-A. Quality assessment of herbal medicines based on chemical fingerprints combined with chemometrics approach: A review. *Journal of Pharmaceutical and Biomedical Analysis*, **2020**.

# ISOLATION OF FOUR TOCOTRIENOL HOMOLOGUES AND PLASTOCHROMANOL-8 FROM PLANT OILS AND THE RAPID 'GREEN' ANALYSIS OF NINE TOCOCHEMANOLS IN COLD-PRESSED PLANT OILS VIA SUPERFICIALLY POROUS PARTICLE PACKED COLUMN TECHNOLOGY AND SUPERCRITICAL FLUID CHROMATOGRAPHY

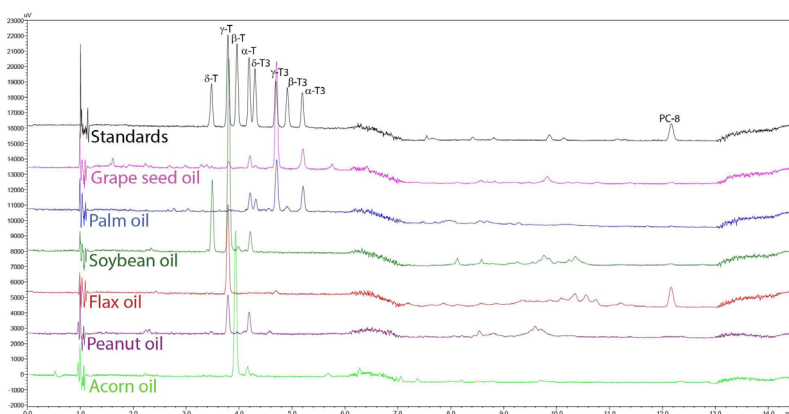
Georgijs Baškirovs, Pawel Gornas

Institute of Horticulture, Graudu iela 1, Dobele, Latvia

E-mail: baskirov@llu.lv

In the present study, four tocotrienol (T3) homologues and plastochochromanol-8 (PC-8) were isolated from plant oils; *Linum usitatissimum* (PC-8), *Bixa orellana* ( $\gamma$ -T3 and  $\delta$ -T3), and *Triticum spelta* bran ( $\alpha$ -T3 and  $\beta$ -T3) by supercritical fluid chromatography (SFC).

The optimized method of tocopherols, tocotrienols, and PC-8 separation via SFC with UV detection was validated on a biphenyl core-shell column. The sample preparation conditions of the plant oils involved a simple dilution in 2-propanol (1:9, v/v), followed by the direct injection into the SFC. A final assay was developed that facilitated the rapid (<15 min) and sensitive (limit of detection within the range of 2.5–7.4  $\mu\text{g/mL}$  and the limit of quantitation within the range of 7.7–22.6  $\mu\text{g/mL}$ ) analyses of tococochromanols in obtained cold-pressed oils from twenty-four different plant species. Furthermore, the method was repeatable and reproducible with % RSD values in the context of standard retention times which ranged within 0.10–0.31 intraday and 0.59–0.79 interday.



**Fig. 1.** Chromatograms of the tococochromanol profile in selected plant oils on the SPP biphenyl column and SFC-DAD system with optimized conditions (oil:2-propanol ratio 1:9 (v/v) and 5  $\mu\text{L}$  injection)

# IMPACT OF AMINO ACID CONTAINING FERTILIZER ON ELEMENTAL AND ISOTOPIC CONTENT IN SPRUCE AND PINE STANDS

**Maris Bertins<sup>1</sup>, Lauma Busa<sup>1</sup>, Dagnija Lazdina<sup>2</sup>, Karlis Dumins<sup>2</sup>, Signija Zake<sup>1</sup>, Maris Klavins<sup>3</sup>, Arturs Viksna<sup>1</sup>**

<sup>1</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia, LV-1004

<sup>2</sup> Latvian State Forest Research Institute 'Silava', 111 Rīgas iela, Salaspils, Latvia, LV-2169

<sup>3</sup> Faculty of Geography and Earth Sciences, University of Latvia, Jelgavas iela 1, Riga, Latvia, LV-1004

E-mail: maris.bertins@lu.lv

More than half of the territory of Latvia is covered with forests – 3.4 million ha. And forest areas still continue to increase due to the afforestation of abandoned agricultural, former mining areas, and also by natural forest growth. As a measure to increase the competitiveness of planted seedlings with forest environment vegetation and addition of lacking nutrient elements to improve growth conditions of trees forest soil fertilization may be used.

One of the most essential nutrients in a plant is nitrogen. As fertilizer nitrogen is typically introduced to the soil in the form of its inorganic salts (nitrates or ammonia salts). But some studies show that introducing nitrogen in a form of an organic compound, for example, in the form of amino acid – arginine (arGrow® Granulat, Arevo AB, Umeå, Sweden). Introducing nitrogen in the form of arginine benefits to improved growth and stress resistance, reduces environmental impact, and simplifies cultivation. It also reduces nitrogen leakage from the soil which leads to reduced use of fertilizers.

The experiment was carried out in four research sites – Vacciniosa mel. dry and drained mineral soil and Myrtillosa dry and drained mineral soil type forests. Carbon and nitrogen isotope ratio and elemental content in needle, branch, root, and soil samples from both fertilized and control plots were analyzed.

One of the methods to determine the effect of soil improver or fertilizer on a plant is to use isotopically marked nitrogen fertilizer together with the light-stable isotope ratio mass spectrometry (IRMS). IRMS (Elemental analyzer EA3000 coupled to Nu instruments mass spectrometer) was used for the determination of the N and C mass fraction and N and C isotope ratio. Inductively coupled plasma mass spectrometry (ICP-MS, Agilent 8900 ICPMS QQQ) was used for the determination of 16 micro- and macroelements in studied samples. Chemometric Agile Tool (CAT) together with statistical software program R was used for the evaluation and statistical treatment of obtained data.

The aim of this study was to evaluate the impact of the amino acid (arginine phosphate) containing fertilizer on changes in isotopic and elemental content in Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) H. Karst) in studied experimental plots.

After fertilization with an arginine phosphate-containing fertilizer, an increase in the mass fraction of nitrogen in spruce needles and a decrease in the value of nitrogen

isotope ratio were observed. In the case of pine seedlings, such a pronounced trend was not observed, which lead to the conclusion that arginine phosphate was not the main source of nitrogen in pine needles. In the second growing season, no significant differences in the nitrogen isotope ratio were observed between fertilized and unfertilized pine samples, but changes in spruce were also observed in the second growing season.

**Acknowledgements.** Research is supported by the Projects “Research program on improvement of the forest growth conditions 2016–2021” (3.5.5-5.1-000z-101-16-31) and “Strengthening the doctoral capacity of the University of Latvia within the framework of the new doctoral model” with project identification No.8.2.2.0/20/I/006, LU registration No. ESS2021/434, co-financed by the European Social Fund.

# APPLICATION OF WASTEWATER – BASED EPIDEMIOLOGY FOR TRACKING HUMAN EXPOSURE TO DEOXYNIVALENOL AND ENNIATINS

Zane Berzina<sup>1,2</sup>, Romans Pavlenko<sup>1,2</sup>, Laura Elina Ikkere<sup>2</sup>, Vadims Bartkevics<sup>1,2</sup>

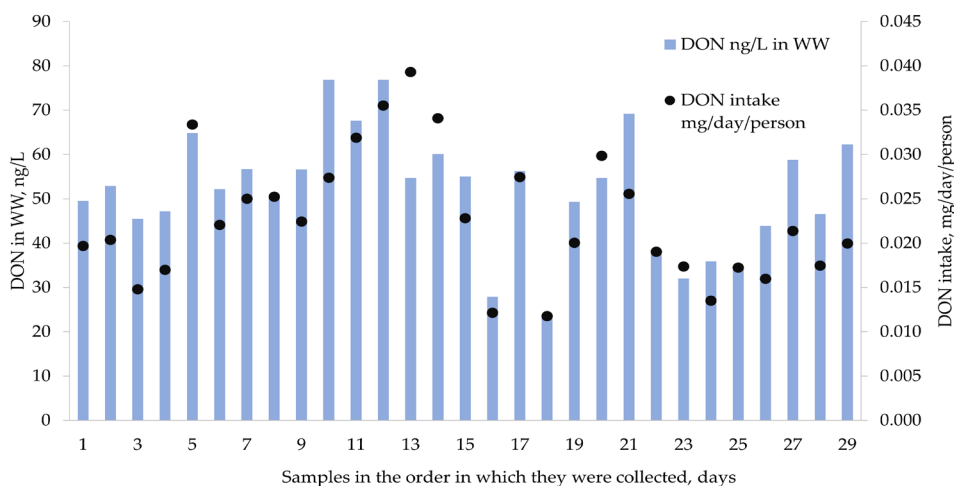
<sup>1</sup> Department of Analytical Chemistry, University of Latvia, Riga, Latvia

<sup>2</sup> Institute of Food Safety, Animal Health and Environment “BIOR”, Riga, Latvia

E-mail: zane.berzina@bior.lv

Wastewater-based epidemiology (WBE) is a promising biomonitoring approach with the potential to provide direct information on human intake and exposure to food and environmental chemicals. WBE based on the normalisation method using a population biomarker 5-hydroxyindoleacetic acid (5-HIAA) is the aim of this study.

For six weeks (from late June to early August) every working day a wastewater (WW) sample was collected from influent in a sewage treatment plant. Free deoxynivalenol was determined in all WW samples. Based on mycotoxin and 5-HIAA content in the samples an intake of deoxynivalenol and enniatins by the population in Riga was estimated.



**Fig. 1.** The detected concentrations of DON (ng/L) in wastewater and normalized concentration of DON (mg/day/person) over 6 weeks

The provisional intake of DON by the human population of Riga was estimated at 325 ng/kg b.w. that set by the European Food Safety Authority is in range of chronic dietary exposure (214–1014 ng/kg b.w. day)<sup>1</sup>. In worst case scenario (if excretion factors are 5% or lower) the sum of average provisional daily intake of enniatins is 1350 ng/kg b.w. day, indicating a potential risk of chronic exposure.

Most of mycotoxins are excreted in the urine as glucuronides. Hydrolysis with  $\beta$ -glucuronidase would release the associated mycotoxins as free compounds. Further research will focus on the development of different hydrolysis methods to detect a wider range of mycotoxins in wastewater.

**Acknowledgements.** This work was supported by the Latvian Council of Science under project No. lzp-2020/2-0128 and “Strengthening of the capacity of doctoral studies at the University of Latvia within the framework of the new doctoral model”, identification No. 8.2.2.0/20/I/006.

## References

[1] Annual Report of the EFSA Journal 2013.

# DISCRIMINATION BETWEEN CONVENTIONALLY AND ORGANICALLY FERTILIZED GRAINS BY FTIR AND <sup>1</sup>H NMR SPECTROSCOPY COMBINED WITH CHEMOMETRICS

**Lauma Buša, Karīna Taranda, Arturs Vīksna, Rihards Klūga**

*University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia*

*E-mail: lauma.busa@lu.lv*

In the last decade, the world has seen growth in interest about the food traceability. This includes not only origins of the food, but also, it's accordance to labelling [1]. In this study the authors researched the possibility of using FTIR and <sup>1</sup>H NMR spectroscopy in combination with chemometric approach to distinguish between conventionally and organically fertilized cereal grains.

Organically and conventionally fertilized barley and triticale grains were analysed in this study. The samples were obtained at Institute of Agricultural Resources and Economics, Priekule Research Centre. For both conventionally fertilized barley and triticale a complex synthetic fertilizer was used. And for biologically fertilized grains, green manure of peas and red clover (*T. pratense*) for barley and triticale, respectively, was incorporated into the soil.

Both FTIR and <sup>1</sup>H NMR spectra showed little or no significant difference between the organically and conventionally fertilized cereal grains. The FTIR spectra showed broad peaks, corresponding to the starch content in the grains. Also, several peaks at 1747 and 2888 cm<sup>-1</sup> were observed that correspond to the protein content in the grains. The main peak shifts in <sup>1</sup>H NMR spectra were observed at 3.69 ppm, 6.27 ppm, 6.90 ppm, 7.28 ppm, 7.52 ppm and are corresponding to ferulic acid. Less intense chemical shifts were observed also for cinnamic acid, p-coumaric acid, caffeic acid and sinapic acid.

For further analysis, the obtained data were investigated using chemometrics – principal component analysis (PCA). After applying the PCA to the data of FTIR spectra, it was concluded that a signal at 1738 cm<sup>-1</sup> and 1750 cm<sup>-1</sup> is specific only for the conventionally fertilized triticale and barley grains, respectively. This peak is characteristic for the amino acids in cereal grains and can be explained by the higher protein content in conventionally fertilized cereals. Regarding the treatment of <sup>1</sup>H NMR spectra with PCA, it was concluded that the chemical shifts of ferulic acid in the organically grown barley and triticale grains were more intense and could be used to discriminate between cereal grains from different fertilization regimes.

## References

[1] Kniese, J.; Race, A. M.; Schmidt H. J. *Cereal Sci.*, **2021**, *101*.



# SYNTHESIS OF IRON HEXACYANOFERRATE IMOBILISED ON CELLULOSE ACETATE FOR CAESIUM SORPTION FROM AQUATIC ENVIRONMENTS

Ugis Eismonts<sup>1</sup>, Maris Bertins<sup>2</sup>, Kristine Saleniece<sup>1</sup>, Olga Muter<sup>3</sup>, Arturs Viksna<sup>2</sup>, Ingars Reinholds<sup>2, 4,\*</sup>, Andrejs Grinbergs<sup>4</sup>

<sup>1</sup> University of Latvia, Faculty of Medicine, Jelgavas iela 1, Riga, Latvia

<sup>2</sup> Faculty of Chemistry, University of Latvia, Jelgavas iela 1, Riga, Latvia

<sup>3</sup> Institute of Microbiology and Biotechnology, University of Latvia, Riga, Latvia

<sup>4</sup> Institute of Chemical Physics, University of Latvia, Jelgavas iela 1, Riga, Latvia

E-mail: ingars.reinholds@lu.lv, ugis.eismonts@gmail.com

The present study aims development of iron hexacyanoferrate (PB) cellulose acetate (CA) sorbent for the removal of radioactive caesium, rubidium, and thallium from contaminated water environments. The synthesis of PB-CA sorbent conducted by ultrasound assisted micro nozzle technique provided in situ immobilisation of sorbent particles on chemically cleaned of non-used cigarette butt fiber materials. The experiments were provided in freshwater aquariums at laboratory, by using Cs-133 chloride as the model substance added to the aquarium water

The experiments of Cs accumulation studies were provided in the ecosystem containing *Ceratophyllum submersum* and *Pomacea bridgesii* and PB-CA sorbent added to the water filtration system. Obtained results showed that despite the presence of PB as a sorbent, still notable accumulation of Cs occurred also in plants *Ceratophyllum submersum* and living organisms *Pomacea bridgesii*. In the process of this study 95% of introduced Cs was accumulated on PB while 3% was accumulated in *Ceratophyllum submersum* and 1% in the flesh of *Pomacea bridgesii*. During these studies sorption capacity of used PB sorbent was evaluated and was equal to 17.8 mgCs/gPB. The sorbent capacity is comparable to that reported in the studies [1] indicating effectiveness of the developed sorbent for Cs removal from the contaminated water.

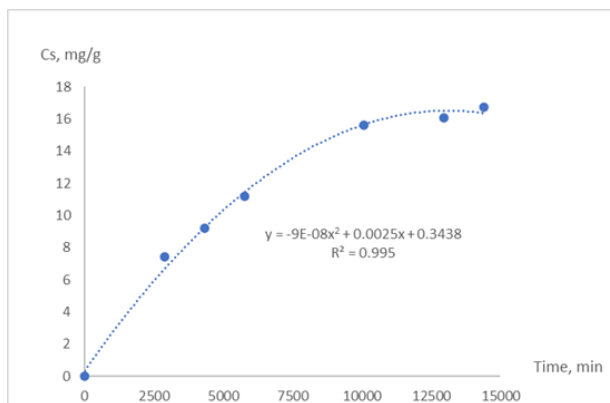


Fig. 1. Sorption of Cs on PB-CA in dependence from time

Obtained experimental data allowed to characterise kinetic model of Cs sorption on PB. The experimental data corresponded to the Lagergren's pseudo-second order kinetic model and can be characterized with sorption capacity at equilibrium which corresponds to 25 mg/g.

**Acknowledgements.** funding from the LCS project lzp-2020/2-0213 and the Ltd. "MikroTik" supported UL Foundation project "Creating extemporal prescription of high toxic and radioactive compounds of cesium, thallium and rubidium antidote" is acknowledged.

## References

[1] Sangvanich, T., et al. *J. Hazard. Mater.* **2010**, 182, 225–231.

# CHARACTERISATION OF SUBERINIC ACIDS AND THEIR POTENTIAL APPLICATIONS

**Daniela Godina**

*University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia  
Biorefinery Laboratory, Latvian State Institute of Wood Chemistry, Riga, Latvia  
E-mail: daniela.godina@kki.lv*

Global sustainability challenges prompt the world to modify their strategies and shift from a fossil-fuel-based economy to a bio-resources-based one and to the production of renewable biomass chemicals. Different processes exist that allow the transformation of raw biomass into desirable bio-based products and/or energy. Depolymerized suberinic acids can be considered as an alternative resource to develop bio-polyols that can be further used in polymeric material production.

Birch (*Betula Pendula*) outer bark was used as a raw material to obtain the suberinic acids. Birch outer bark was extracted with ethanol and depolymerized with potassium hydroxide/ethanol solution. By acidifying the filtrate to pH 5.0, 3.0 and 1.0, after washing 1 and 2 times, filtration and drying at 50 °C and 130 °C, 12 suberinic acid fractions were obtained.

In order to determine the chemical properties of obtained suberinic acid samples, several characteristics were determined – total phenolic content (TPC), acid number, saponification number, epoxy groups and hydroxyl number using potentiometric titration. Two instrumental methods also were developed with GC-MS and SEC-RID. GC-MS analysis was performed with 2 separate sample preparation methods to characterise both monomeric fraction as well as polymeric fraction present in suberinic acid samples.

At pH 1, by increasing the drying temperature of suberinic acids, the relative amount of hydroxy acids increases, but at pH 3 and pH 5 the opposite trend is observed. By increasing the drying temperature and the pH value did not change the relative amount of diacids. At pH 5, the relative amount of aromatic compounds decreased when suberinic acid drying temperature was increased. Samples in addition to monomeric fraction also contained a significant amount of polymeric suberin fraction, which cannot be seen by GC-MS without complete hydrolysis. Therefore, two sample preparation methods were used and GC-MS results compared. It was concluded that after depolymerization, all samples are dominated by hydroxy acids separated from the suberin macromolecule. Suberinic acids were tested in bio-polyol synthesis reaction and results were promising.

**Acknowledgements.** This research is funded by the project “Birch bark as a valuable renewable raw material for producing formaldehyde-free particle boards and suberinic acids polyols for the development of polyurethanes”, project No. 1.1.1.1/19/A/089.

# BIOACTIVITY ENHANCEMENT OF PEO COATINGS BY INTRODUCTION OF AMORPHOUS CALCIUM PHOSPHATE PARTICLES

**Vladlens Grebņevs<sup>1,2</sup>, Şahin Altundal<sup>3</sup>, Roman Viter<sup>3</sup>, Mateusz Dulski<sup>4</sup>, Marta Wala<sup>2</sup>, Katarzyna Leśniak-Ziółkowska<sup>2</sup>, Arturs Vīksna<sup>1</sup>, Wojciech Śimka<sup>2</sup>**

<sup>1</sup> *University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia*

<sup>2</sup> *Silesian University of Technology, Faculty of Chemistry, B. Krzywoustego str. 6, Gliwice, Poland*

<sup>3</sup> *University of Latvia, Institute of Atomic Physics and Spectroscopy, Jelgavas iela 3, Riga, Latvia*

<sup>4</sup> *University of Silesia, Institute of Materials Engineering, 75 P. Piech. 1A, 41-500 Chorzów, Poland*

*E-mail: vladlens.grebnevs@lu.lv*

Bioactivity is one of the key indicators of implant coating quality and their suitability in bone disease treatment. In vivo it lies in the ability of a certain material to form strong and stable bonds with living tissues. While for its evaluation in vitro, simulated body fluid tests are the most commonly used, based on immersion of a test sample in the environment with physiological conditions and assessment of hydroxyapatite layer growth rate on its surface [1].

The history of bioactive coatings began right after the rise of implantology and until this time many important discoveries related to their fabrication have been made. Numerous studies were devoted to the application of different bioactive compounds, mainly calcium phosphates, on the metal surfaces, using both the solid particles themselves, as well as indirectly in form of solutions, suspensions and gels [2]. Nevertheless, the search for new, simpler and more rational technologies nowadays remains relevant, opening wide opportunities for still few studied, but promising methods, one of which is plasma electrolytic oxidation (PEO).

PEO is an electrochemical procedure that implies interactions occurring between metallic anode and electrolyte at increased voltages, typically 200 V or higher. Under these conditions, short-lived sparks emerge, which, accompanied by oxygen and heat release, cause resolidification and melting of the anode surface and ultimately lead to formation of porous oxide layer. By adding calcium phosphate particles to the electrolyte, it becomes possible to incorporate them into resulting composite and subsequently modify its physicochemical properties, including bioactivity.

It is believed that the use of crystalline calcium phosphate particles for production of implant coatings is preferred, since the biological form of hydroxyapatite, the main inorganic component of mammalian solid tissues, has a crystalline structure rather than amorphous. Indeed, higher crystallinity is accompanied by better adhesion and proliferation of cells on the surface, as well as by lower coating degradation rate [3]. As a result, researchers when working with well-known coating methods successfully rely on this principle.

Howbeit, the findings of this study allow us to declare that specifically for PEO method utilization of amorphous particles is more expedient, contributing to superior implant coating characteristics against crystalline ones. As confirmed by comprehensive comparison of various physicochemical parameters, it was concluded that amorphous particle incorporation results in calcium-richer bioactive oxide layer. Lower density, less pronounced shape and increased specific surface area are supposed to be the factors that allow these particles to get efficiently incorporated.

## References

- [1] Samavedi, S.; Whittington, A. R.; Goldstein, A. S. *Acta Biomaterialia*, **2013**, *9*, 8037–8045.
- [2] Jaafar, A.; Hecker, C.; Árki, P.; Joseph, Y. *Bioengineering*, **2020**, *7*, 127.
- [3] Roy, M.; Bandyopadhyay, A.; Bose, S. *Surf. & Coat. Tech.*, **2011**, *205*, 2785–2792.

# RECENT TRENDS IN PESTICIDE ANALYSIS BY TWO-DIMENSIONAL LIQUID CHROMATOGRAPHY – MASS SPECTROMETRY

**Āris Jansons, Vadims Bartkevičs**

*University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Rīga, Latvia*

*Institute of Food Safety, Animal Health and Environment “BIOR”, Leļupes iela 3, Rīga, Latvia*

*E-mail: arisjanzons@gmail.com*

Pesticide residues and their degradation products can persist on harvested food, as well as in the environment, therefore representing a risk to human and animal health and the environment. The challenges for the pesticide residue analysis are the huge number of possible residues, the chemical diversity of the pesticides, the variety of matrices, and the control of the statutory maximum residue levels that are partly very low [1].

Classical one-dimensional liquid chromatography-mass spectrometry approaches do not always provide the resolving power and selectivity necessary for the analysis of complex samples. To this end, two-dimensional liquid chromatography-mass spectrometry offers a better resolving power and peak capacity and allows decreasing matrix effects as a result of the advanced separation of analytes and matrix components. Furthermore, two-dimensional liquid chromatography-mass spectrometry allows omitting the classical liquid-liquid and solid-phase extraction steps during sample preparation for some samples [2].

Recent developments in pesticide analysis by two-dimensional liquid chromatography-mass spectrometry could be divided in three large research directions.

Firstly, the aim of the researchers is to simultaneously identify as many different pesticides, for example, QuEChERS amenable and highly polar ones and other food contaminants like mycotoxins, plant growth regulators, alkaloids in different matrices within a single analytical run. By means of using two-dimensional liquid chromatography-mass spectrometry it also becomes more viable to analyse complicated and dirty matrices such as hops, tea and tobacco which used to be quite complicated due to matrix interference.

Secondly, the task of the researchers is to separate and quantify enantiomers of chiral pesticides that have similar physical and chemical properties, but differ in their toxicity and biological activity, because biotransformation of chiral molecules could be stereoselective. Likewise, enantiomers could have different degradation patterns in the environment [3].

Thirdly, the desire of the researchers is to replace classical QuEChERS protocol-based sample preparation with two-dimensional liquid chromatography-mass spectrometry as the only tool of sample analysis and preparation without any further manual sample pre-treatment except extraction with, for example, acetonitrile or acetonitrile-water mixture.

## References

- [1] Muehwald, S.; Rohn, S.; Buchner, N. Evaluating the applicability of a two-dimensional liquid chromatography system for a pesticides multi – screening method. *Journal of Chromatography A*, **2019**, *1599*, 95–107.
- [2] Kittlaus, S.; Schimanke, J.; Kempe, G.; Speer, K. Development and validation of an efficient automated method for the analysis of 300 pesticides in foods using two-dimensional liquid chromatography - tandem mass spectrometry. *Journal of Chromatography A*, **2013**, *1283*, 98–109.
- [3] Zeng, H.; Xie, X.; Huang, Y.; Chen, J.; Liu, Y.; Zhang, Y.; Mai, X.; Deng, J.; Fan, H.; Zhang, W. Enantioseparation and determination of triazole fungicides in vegetables and fruits by aqueous two-phase extraction coupled with online heart - cutting two-dimensional liquid chromatography. *Food Chemistry*, **2019**, *301*, 125265.

# DETERMINATION OF LATVIAN HONEY FLORAL ORIGINS USING IRMS, UHPLC-HRMS, ICP-MS, FT IR AND 1H-NMR

Krišs Dāvids Labsvārds<sup>1,2</sup>, Vīta Rudoviča<sup>1</sup>, Jānis Ruško<sup>2</sup>, Rihards Klūga<sup>1</sup>,  
Lauma Buša<sup>1</sup>, Māris Bērtiņš<sup>1</sup>, Ineta Eglite<sup>3</sup>, Jevgeņija Naumenko<sup>1</sup>,  
Marina Šalajeva<sup>1</sup>, Arturs Vīksna<sup>1</sup>

<sup>1</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Rīga, Latvia

<sup>2</sup> Institute of Food Safety, Animal Health and Environment "BIOR", Lejuupes iela 3, Rīga, Latvia

<sup>3</sup> Latvian Beekeeping Association, Rīgas iela 22, Jelgava, Latvia

E-mail: kriss\_davids.labsvards@lu.lv

Natural bee honey is a sweet product made by honeybees (*Apis mellifera* L.) and it has grown in scientific interest in the past decade. Modern and efficient methods of honey analysis are needed in order to assure products quality. One of many honey quality cornerstones is floral origins determination. Monofloral honey has to be gathered from one major floral source at certain threshold level, so presence of other plant interference is inevitable, thus making this a difficult task [1].

To investigate possibilities of Latvian honey floral origins determination, the wide instrumental analysis of isotope ratio mass spectrometry (IRMS), ultra-high performance liquid chromatography-high resolution mass spectrometry (UHPLC-HRMS), inductively coupled plasma-mass spectrometry (ICP-MS), Fourier transform infrared spectroscopy (FT IR) and nuclear magnetic resonance (NMR) methods were performed to 78 natural honey samples obtained from local Latvian manufacturers. The true floral origins for used honey samples were verified by melissopalynology analysis. Additionally, chemometric approach was performed using principal component analysis (PCA) [2].

The preliminary results show that depletion of  $\delta^{15}\text{N}$  values might be useful indicator for heather honey due values were statistically different after ANOVA one way test and PCA indicated characteristics of C and N percentage in proteins to monofloral heather honey. Increased rutin levels were observed to buckwheat honey using UHPLC-HRMS. PCA results of FT IR spectra and ICP-MS showed potential to distinguish buckwheat honey from other floral sources while PCA of binned NMR spectra showed the most diversity of honey floral origins assessment.

**Acknowledgements.** This work was supported by grant "Recognition of monofloral honey of Latvian origin using nuclear magnetic resonance, chromatographic, isotope ratio mass spectrometry and chemometric methods" grant Nr. LZP-2020/2-0200 & "Strengthening of the capacity of doctoral studies at the University of Latvia within the framework of the new doctoral model", identification No. 8.2.2.0/20/I/006.



## References

- [1] Puścion-Jakubik, A.; Borawska, M. H.; Socha, K. Modern Methods for Assessing the Quality of Bee Honey and Botanical Origin Identification. *Foods*, **2020**, *9*, 1028. <https://doi.org/10.3390/foods9081028>
- [2] Labsvards, K. D.; Rudovica, V.; Kluga, R.; Rusko, J.; Busa, L.; Bertins, M.; Eglite, I.; Naumenko, J.; Salajeva, M.; Viksna, A. Determination of Floral Origin Markers of Latvian Honey by Using IRMS, UHPLC-HRMS, and 1H-NMR. *Foods*, **2022**, *11*, 42. <https://doi.org/10.3390/foods11010042>

# INVESTIGATION OF NANOSTRUCTURED $\text{Bi}_2\text{Se}_3$ THIN FILMS AS ANODES FOR AQUEOUS RECHARGEABLE LITHIUM-ION BATTERIES

Vitālijs Lazarenko<sup>1</sup>, Yelyzaveta Rublova<sup>1</sup>, Raimonds Meija<sup>1</sup>, Jana Andžāne<sup>1</sup>, Vanda Voikiva<sup>1</sup>, Arturs Vīksna<sup>2</sup>, Donāts Erts<sup>1, 2</sup>

<sup>1</sup> Institute of Chemical Physics, University of Latvia, Raina blvd. 19, Riga, Latvia

<sup>2</sup> University of Latvia, Faculty of Chemistry, Raina blvd. 19, Riga, Latvia

E-mail: vitalijs.lazarenko@lu.lv

In the last decade, lithium-ion batteries (LIBs) have dominated the world as the most efficient electrical energy storage device. In comparison with lead-acid or carbon-zinc batteries LIBs have a supreme energy density ( $> 200 \text{ Wh kg}^{-1}$ ), cycle life (up to 3000 cycles), and energy efficiency ( $> 95\%$ ). Despite their huge advantages, however, the use of non-aqueous electrolytes (e.g.,  $\text{LiBF}_4$ ,  $\text{LiPF}_6$ ) is still considered to be a serious drawback of LIBs, as they are flammable, and can be unfriendly to the ambient environment. To solve these shortcomings, the alternative way is to use aqueous electrolytes (e.g.,  $\text{LiNO}_3$ ,  $\text{Li}_2\text{SO}_4$ ). The first concept of aqueous rechargeable lithium-ion batteries (ARLIBs) was demonstrated in 1994 by Dahn and his research group by showing a possible perspective of the application of lithium aqueous electrolytes.  $\text{Bi}_2\text{Se}_3$  is a unique material with a layered structure that has already shown great promise as an anode in LIBs.

This research demonstrates the investigation of the electrochemical properties of  $\text{Bi}_2\text{Se}_3$  thin films with formed solid electrolyte interphase (SEI) and  $\text{Bi}_2\text{O}_3$  layer. As an electrolyte 5 M  $\text{LiNO}_3$  was used which is more electrochemically stable than  $\text{Li}_2\text{SO}_4$  and  $\text{LiCl}$ .  $\text{Bi}_2\text{Se}_3$  thin films were synthesized using physical vapour deposition. In this work was applied different electrochemical measurements techniques (cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and charge/discharge) to investigate the electrochemical properties.

The analysis of  $\text{Bi}_2\text{Se}_3$  thin films in the lithium aqueous electrolyte was investigated for the first time to show the perspective application as anode for ARLIBs and the difference of electrochemical properties between formed SEI and  $\text{Bi}_2\text{O}_3$  layer. Results of this work demonstrated that  $\text{Bi}_2\text{Se}_3$  thin films with formed SEI layer ( $\text{Li}_2\text{O}$  and  $\text{Li}_2\text{CO}_3$ ) on the electrode surface ensure high diffusivity of  $\text{Li}^+$ , high electrochemical stability, and high capacity up to 100 cycles.

**Acknowledgements.** This research was funded by the European Regional Development Fund Project (ERDF) No. 1.1.1.1/19/A/139. Y. R. acknowledges the support of post-doctoral ERDF project No. 1.1.1.2/VIAA/4/20/694. V. L. acknowledges the support of “Strengthening of the capacity of doctoral studies at the University of Latvia within the framework of the new doctoral model”, identification No. 8.2.2.0/20/I/006.

# TEMPERATURE EFFECT ON THE YIELD OF METHANE FROM BOG SLUDGE AND REED RAW MATERIALS

**Sergejs Osipovs, Aleksandrs Pučkīns**

*Daugavpils University, Department of Applied Chemistry, Parādes iela 1A, Daugavpils, Latvia*

*E-mail: sergejs.osipovs@du.lv*

Biogas is a gaseous energy resource that can be obtained by anaerobic fermentation using biomass. The main component of biogas is methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ), which also includes other gases with certain physical properties. Biogas is a renewable energy resource that does not pollute the environment and the air. Biogas production reduces landfill growth and reduces water and soil pollution. The trend of biogas technologies is improving every time, thus the supply for biogas production is increasing. Capital investment in biogas plants requires relatively low costs. Their use reduces the greenhouse effect, as decomposing products emit  $\text{CH}_4$  and  $\text{CO}_2$  gases, which trap infrared (thermal) radiation reflected from the earth's surface [1].

Unlike fossil fuels, biogas is a fully renewable resource because it is produced from biomass. Biogas will not only improve the country's energy balance, but will also make a major contribution to conserving natural resources and improving the environment [2].

The research summarizes information on biochemical processes of biogas production and the parameters that affect the results of its production. The research examines the result of obtaining biogas from bog sludge and a mixture of crushed reed. Particular attention is given to temperature, as a parameter that affects the results of methane and biogas production. In order to perform the work and obtain biogas, bog sludge from Viļaka region, and bog reeds from Daugavpils Esplanāde park were used in, which were dried and divided into components: stems, leaves, flowers. In order for anaerobic fermentation processes to be possible, digestate from the biogas plant "Skaista", Daugava region, Skrudalienas parish was used. Bioreactor EDF-5.4\_2 (manufactured by "Biotehniskais centrs", Latvia) was used for research.

The biogas yield during the bioprocess depends on the effect of temperature, the best results in our study were obtained at a temperature of 40 °C. During the experiment, 2.78 L of biogas with an average methane content of 38.7% was obtained from a mixture of bog sludge and crushed reeds. If the content of organic compounds in the sludge was higher, the biogas yield would increase during the process. It is more advantageous to use the raw material mixture for biogas production. The proportion of methane in biogas was the best at a temperature of 38 °C – 39.9%, but at this temperature regime the total volume of biogas turned out to be about 15% less. The worst results were obtained at a temperature of 42 °C – both in terms of the volume of biogas and the proportion of methane in it.

## References

- [1] Bhardwaj, S.; Das, P. *Int J Res Eng Technol.* **2017**, *4*(10), 890–893.
- [2] "Akvakultūras daudzgadu stratēģiskās pamatnostādnes 2014.–2020. Gadam", 2013. [Online]. [https://www.zm.gov.lv/public/files/CMS\\_Static\\_Page\\_Doc/00/00/00/35/82/akvakultura\\_2014.pdf](https://www.zm.gov.lv/public/files/CMS_Static_Page_Doc/00/00/00/35/82/akvakultura_2014.pdf)

# SEPARATION OF BLACK ALDER BARK EXTRACTS USING SOLID PHASE EXTRACTION TO OBTAIN FRACTIONS WITH IMPROVED PROPERTIES

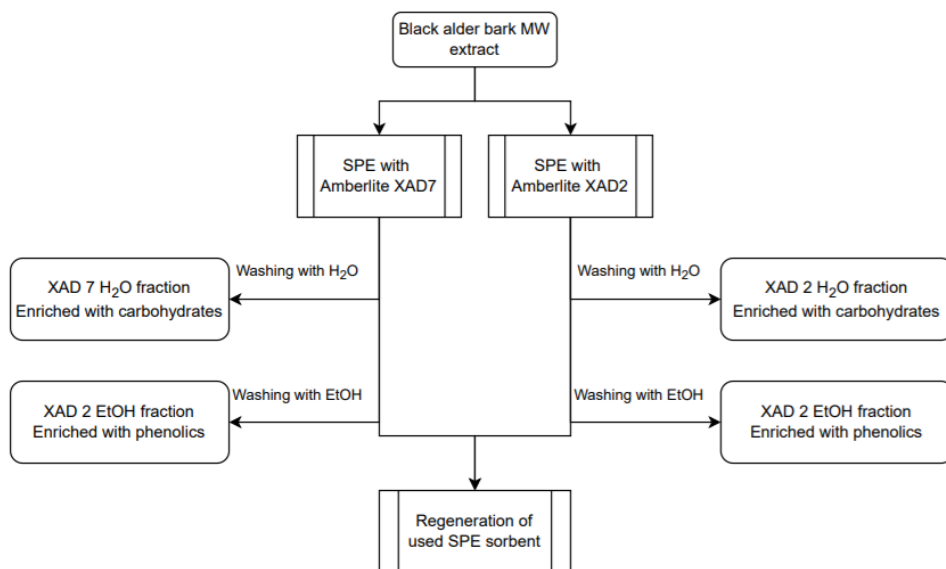
Matiss Pals<sup>1,2</sup>, Maris Lauberts<sup>2</sup>, Jevgenija Ponomarenko<sup>2</sup>,  
Alexandr Arshanitsa<sup>2</sup>

<sup>1</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

<sup>2</sup> Laboratory of Lignin chemistry, Latvian State Institute of Wood Chemistry, Riga, Latvia

E-mail: matiss.pals@kki.lv

Black alder bark (*Alnus glutinosa*) refers to the lignocellulosic biomass which together with the main cell wall components contains a wide range of polyphenolic extractives including diarylheptanoids which are recognized as a natural antioxidants [1]. Therefore, black alder bark extract is a resource with wide range of possible practical application including antioxidative additives in cosmetics, or/and as a technical antioxidant in polymeric chemistry. In this way microwave assisted water extraction of black alder bark revealed itself as a fast and energy effective methods of extractives isolation. To increase the antioxidative properties of isolated products via increasing of polyphenolic concentration in them the Solid Phase Extraction (SPE) was utilised with two different sorbents of different polarity (Amberlite XAD2 and Amberlite XAD7).



**Fig 1.** Process workflow for extract fractionation using solid phase extraction

This approach allowed successfully fractionate black alder bark extract with total mass recovery being 95%. Obtained water fractions were enriched with carbohydrates,

while obtained ethanol (EtOH) fractions were enriched with phenolic type compounds and showed higher antioxidative activity comparable to that of non-fractionated extracts.

**Acknowledgements.** This research is funded by the project No. 1.1.1.1/18/A/182.

## References

- [1] Lauberts, M.; Pals, M. Antioxidant Activity of Different Extracts from Black Alder (*Alnus glutinosa*) Bark with Greener Extraction Alternative. *Plants*, **2021**, *10*, 2531, doi:10.3390/plants10112531.

# DIETARY EXPOSURE ASSESSMENT TO PERFLUOROALKYL SUBSTANCES

Elina Pasecnaja<sup>1,2</sup>, Dzintars Zacs<sup>2</sup>

<sup>1</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

<sup>2</sup> Institute of food safety, animal health and environment "BIOR", Lejupes iela 3, Riga, Latvia

E-mail: elina.pasecnaja@bior.lv

Per- and polyfluorinated alkyl substances (PFASs) comprise a large group of anthropogenic chemicals which are ubiquitous environmental contaminants. In 2020 European Food Safety Authority (EFSA) established a tolerable weekly intake (TWI) of 4.4 ng/kg bw per week for the sum of four PFASs: perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS) and perfluorooctanesulfonic acid (PFOS).

Many researchers have attempted to estimate the dietary intake of PFASs in different European countries. These dietary intake assessments were based on the average body weight of 70 kg and the consumption rates from national diet surveys. The tolerable daily intake (TDI) limit of 0.63 ng kg<sup>-1</sup> b.w.<sup>-1</sup> established for the  $\Sigma_{4\text{PFASs}}$  by EFSA was exceeded according to most studies (Fig. 1). Many studies estimated the TDI using a very limited basket of food types, resulting in underestimation as the figures given did not reflect the objective dietary intake of PFAS. Difficulties in comparison of the exposure estimates from different studies appear since there is no consensus whether the observed data should be evaluated on the upperbound (UB) or lowerbound (LB) basis. The exposure is likely underestimated via the the LB approach, whereas it is certainly overestimated via the UB approach. Therefore, to reduce the uncertainties in occurrence data, more sensitive analytical methods or improved analytical protocols should be applied to ensure the analysis of PFASs at occurrence levels that comply with the newly established EFSA TWI of 4.4 ng kg<sup>-1</sup> b.w.<sup>-1</sup>.

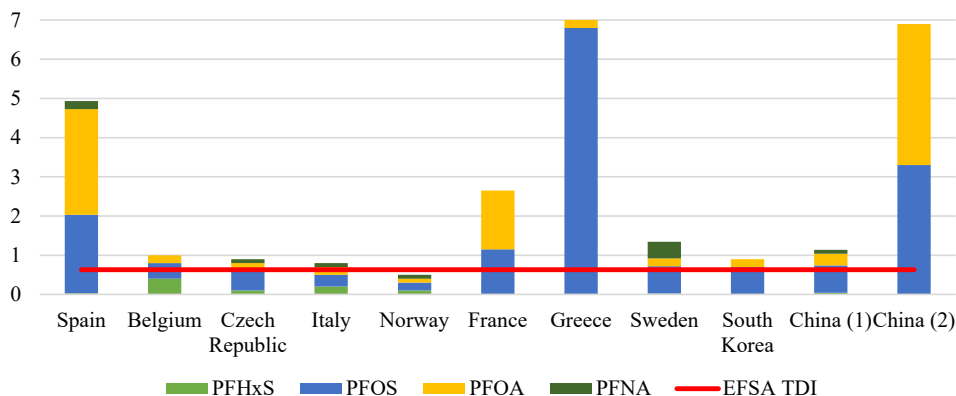


Fig. 1. Dietary intake of  $\Sigma 4\text{PFASs}$  (ng kg bw<sup>-1</sup> day<sup>-1</sup>) from different countries

## References

- [1] Pasecnaja, E.; Bartkevics, V.; Zacs, D. Occurrence of selected per- and polyfluorinated alkyl substances (PFASs) in food available on the European market – a review on levels and human exposure assessment *Chemosphere*, **2022**, 287.

# QUALITATIVE FINGERPRINTING OF PSYCHOACTIVE PHARMACEUTICALS, ILLICIT DRUGS, AND RELATED HUMAN METABOLITES IN WASTEWATER DURING THE COVID-19 PANDEMIC IN RIGA, LATVIA

Ingus Perkons<sup>1</sup>, Laura Elina Ikkere<sup>1,2</sup>, Veronika Sukajeva<sup>1</sup>, Iveta Pugajeva<sup>1</sup>

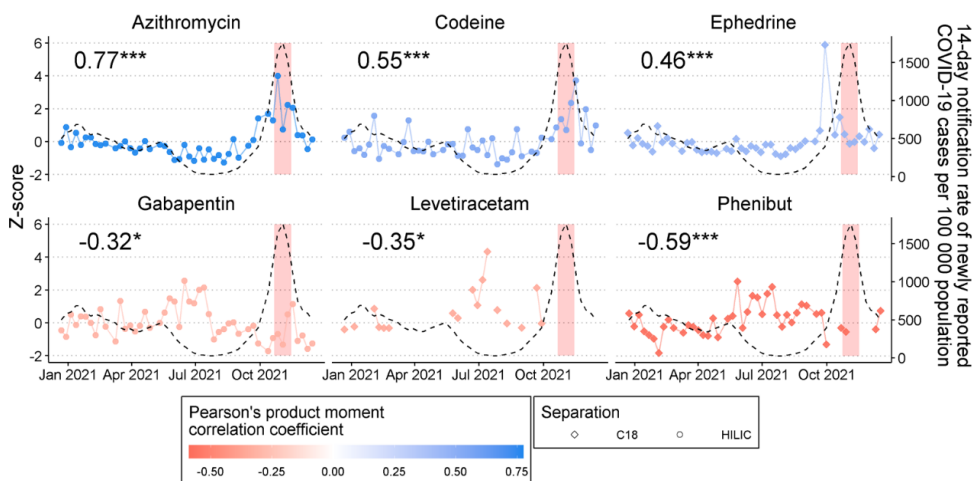
<sup>1</sup> Institute of Food Safety, Animal Health and Environment "BIOR", Leļupes iela 3, Riga, Latvia, LV-1076

<sup>2</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

E-mail: [ingus.perkons@bior.lv](mailto:ingus.perkons@bior.lv)

Multiple studies have outlined that the Covid-19 pandemic and government interventions to curb the spread of the virus are likely to have an effect on mental health and substance use patterns [1]. In this study, we explored the presence of psychoactive pharmaceuticals, illicit drugs and related human metabolites in 24-h composite wastewater samples that were sampled weekly over the period of twelve months (December 22, 2020 to December 14, 2021) from the central WWTP of Riga, Latvia. The analysis was performed via qualitative suspect screening approach using three separate high-resolution mass spectrometry (HRMS) methods, which relied on reversed-phase liquid chromatography (RPLC), hydrophilic interaction liquid chromatography (HILIC) and direct infusion HRMS.

In total, 39 out of 149 substances were detected throughout the sampling period, including pharmaceuticals (e.g., antiepileptics, antidepressants and antipsychotics), illicit drugs (e.g., MDMA, cocaine, amphetamine, etc.) and new psychoactive substances (alpha-PVP).



**Fig. 1.** Normalized peak areas of selected APIs that were identified during the study from December 22, 2020 till December 12, 2021. The dashed line represents the 14-day notification rate of newly reported Covid-19 cases per 100 000 population in Latvia



The data were evaluated in relation to Covid-19 incidence rate and the extent of containment and closure policies. For some compounds we observed temporal changes that may be potentially linked with the consequences of the pandemic. For instance, higher detection rates were observed for some illicit drugs during periods, when restrictions on public events were relaxed.

## References

- [1] Montgomery, A. B.; Bowers, I.; Subedi, B. Trends in Substance Use in Two United States Communities during Early Covid-19 Lockdowns Based on Wastewater Analysis. *Environ. Sci. Technol.*, **2021**, *8*, 890–896.

# **Section of Physical Chemistry**

# COST GAINS AND CO<sub>2</sub> REDUCTION IN GREENHOUSE HEATING BY AIR TO WATER HEATPUMP LATVIA DURING 2<sup>nd</sup> HALF OF 2021

**Agris Auce<sup>1</sup>, Indulis Horns<sup>1</sup>, Aivars Jeremuss<sup>2</sup>, Ādolfs Ruciņš<sup>2</sup>,  
Mareks Drozdovs<sup>3</sup>, Ivars Auce<sup>4</sup>, Uģis Grīnbergs<sup>5</sup>**

<sup>1</sup> *University of Latvia, Institute of Chemical Physics, Jelgavas iela 1, Rīga, Latvia*

<sup>2</sup> *Latvia University of Life Sciences and Technology, 2 Lielā iela, Jelgava, Latvia, LV-3001*

<sup>3</sup> *SIA Rītausma, "Saules", Sala, Salas pag., Jēkabpils nov., Latvia, LV-5230*

<sup>4</sup> *Institute of Advanced Technologies, Čiekurkalna 1. līnija 33, Rīga, Latvia, LV-1026*

<sup>5</sup> *Baltic Open Solutions Center, SIA, Ainažu iela 13, Saulkrasti, Saulkrastu nov., Latvia, LV-2160,*

*E-mail: agris.auce@lu.lv*

Use of air to water heatpump (AWHP) to reduce CO<sub>2</sub> emissions from greenhouse heating were investigated by calculating the running costs of AWHP and natural gas boilers. Real climatic conditions and heating regimes of SIA Rītausma industrial greenhouse production facility in south east of Latvia were used for the calculations. COP of commercially available Hitachi 10 kw heating power air-to water heatpump and the Nordpool day-ahead Latvia electricity prices were used. AWHP COP was adjusted to the actual outdoor temperature by using the third-degree polynomial fitted to the COP declared by the producers at 4 standard temperatures: -7, 2, 7, 12 °C. The cost of gas heating was calculated from the actual price of natural gas delivered to the facility and the actual gas boiler which has a 0,94 COP.

**Results.** 2nd half of 2021 was extraordinary in terms of hikes in both electricity and natural gas prices. For most of the time AWHP economically outperformed gas heating by a large margin. During periods of very high electricity prices and low temperatures the gas was much better option economically. During the time period studied the AWHP had economic advantages from August to November 2021 and gas heating was better during most of December 2021. By adding heatpumps to the existing gas heating system and running a hybrid system it proved possible to lower heating costs at least twice as compared to the existing cost of heating by natural gas alone. Addition of heatpumps to existing gas heating allows for at least 2-to-3-fold reduction of CO<sub>2</sub> emissions and a significant reduction of the heating costs. Phase transition materials like paraffins with phase transition T 50–60 °C were found to be the most efficient storage media for the heat generated by AWHP in order to benefit from low electricity night prices at Nordpool.

**Summary.** Calculations using theoretical performance of heatpumps and market price for electricity and gas in Latvia during 2nd half of 2021 show that it is possible to achieve 2-to-3-fold reduction in CO<sub>2</sub> emissions and simultaneously significantly decrease the heating costs by adding air to water heatpump to existing gas heating for a greenhouse in Latvia.

**Acknowledgements.** Project “Research of effective heat production and supply solutions in covered areas” is supported by the Ministry of Agriculture and the Rural Support service in the programme 16.1 “Support for the establishment and operation of operational groups of the EIP for agricultural productivity and sustainability”. Nr. 18-00-A01612-000023.

# GRAPHENE IN LAYERED NANOSTRUCTURES

**Margarita Baitimirova<sup>1</sup>, Jana Andzane<sup>1</sup>, Roman Viter<sup>2</sup>, Mikhael Bechelany<sup>3</sup>, Donats Erts<sup>1</sup>**

<sup>1</sup> *Institute of Chemical Physics, University of Latvia, Jelgavas iela 1, Riga, Latvia*

<sup>2</sup> *Institute of Atomic Physics and Spectroscopy, University of Latvia, Jelgavas iela 3, Riga, Latvia*

<sup>3</sup> *University of Montpellier, European Institute of Membranes, CNRS, Place Eugene Bataillon 34095, Montpellier, France*  
*E-mail: margarita.baitimirova@lu.lv*

Graphene – 2D carbon allotrope – is a unique nanomaterial due to its physical properties: semiconductor with zero band gap, high electrical and thermal conductivity, high optical transparency and mechanical strength. Such properties open wide applications of graphene in many fields such as electronics, optoelectronics, thermoelectrics etc. Combination of graphene with other nanomaterials in layered nanostructures can provide creation of heterostructures with improved physical properties.

In this work the improvement of crystal structure and physical properties of nanomaterials combining them with graphene will be considered on graphene/Bi<sub>2</sub>Se<sub>3</sub>/graphene layered structures [1], graphene/ZnO nanolaminates [2], graphene/Bi<sub>2</sub>Se<sub>3</sub>/ZnO heterostructures [3]. The enhancement of properties is predicted from changes in crystal structure during synthesis of nanostructures on graphene substrates (graphene, ZnO and Bi<sub>2</sub>Se<sub>3</sub> have similar lattice geometry allowing epitaxial growth onto graphene) and due to charge transfer at the interface of created layered structures. For the fabrication of layered structures chemically vapor deposited graphene was transferred onto supporting quartz substrates and for graphene/ZnO nanolaminates – onto ZnO nanostructures. ZnO nanostructured layers were synthesized using atomic layer deposition technique. Bi<sub>2</sub>Se<sub>3</sub> nanostructured coatings were synthesized onto graphene using catalyst-free vapour-solid deposition technique. Morphology and crystal structure of fabricated heterostructures were studied using scanning electron microscopy, atomic force microscopy, X-ray diffractometry. Thermoelectric properties of Bi<sub>2</sub>Se<sub>3</sub> in graphene/Bi<sub>2</sub>Se<sub>3</sub>/graphene layered structures were studied by electrical conductivity and thermoelectric measurements. Optical properties of ZnO in heterostructures were investigated by absorbance and photoluminescence measurements. Correlation between the structure, optical and thermoelectrical properties of semiconductor nanolayers in layered heterostructures is analyzed. Possible mechanisms of improving the optical and thermoelectric properties of graphene-containing layered nanostructures are proposed. Fabricated nanostructures showed the good potential for applications in thermoelectric and optoelectronic devices.

## References

- [1] Baitimirova, M.; Andzane J.; Petersons, G.; Meija, R.; Poplauskis, R.; Romanova, M.; Erts D. J. *Mater. Sci.*, **2016**, *51*, 8224–8232.

- [2] Baitimirova, M.; Viter, R.; Andzane, J.; Lee, A.; Voiry, D.; Iatsunskyi, I.; Coy, E.; Mikoliunaite, L.; Tumenas, S.; Zaleski, K.; Balevicius, Z.; Baleviciute, I.; Ramanaviciene, A.; Ramanavicius, A.; Jurga, S.; Erts, D.; Bechalany, B. *J. Phys. Chem. C*, **2016**, *120*, 23716–23725.
- [3] Baitimirova, M.; Andzane J.; Viter, R.; Fraisse, B.; Graniel, O.; Bechalany, M.; Watt, J.; Peckus, D.; Tamulevicius, S.; Erts, D. *J. Phys. Chem. C*, **2019**, *123*, 31156–31166.

# EXPERIMENTAL AND THEORETICAL STUDY OF FREE VOLUME IN SILICON-FUNCTIONALIZED IONIC LIQUIDS

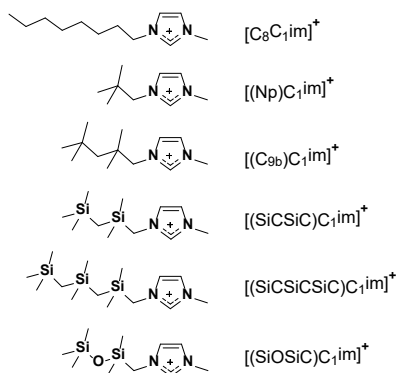
Eduards Bakis<sup>1\*</sup>, Kateryna Goloviznina<sup>2</sup>, Ines Vaz<sup>2</sup>, Agilio Pádua<sup>2</sup>, Margarida Costa Gomes<sup>2</sup>

<sup>1</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

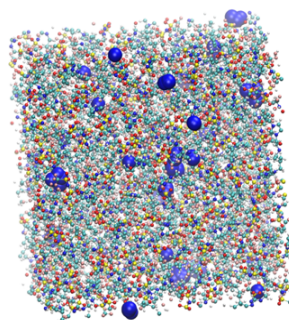
<sup>2</sup> Laboratoire de Chimie de l'ENS Lyon, Lyon, France

E-mail: eduards.bakis@lu.lv

Due to the dominating Coulombic interactions, packing of ions in ionic liquids (ILs) solely depends on ion shape and size. The **free volume** in ILs is thus generally smaller than in molecular liquids. The low volatility and structural tuneability of ILs make them attractive for applications involving **gaseous solutes**. Greater free volume can **entropically** contribute to absorption of gases and, for example, allow selective absorption based on size when other solvent-solute interactions are of comparable energy. **Understanding of design principles** for ILs of higher free volume is therefore crucial towards efficient IL-based materials for gas capture and separation.



**Fig. 1.** Structures of IL cations studied herein



**Fig. 2.** Snapshot of a simulation box of [(Np)C<sub>1</sub>im][NTf<sub>2</sub>] and 1.9Å cavities

In this work we have **designed, prepared and characterised** new **heavily branched** ILs containing several silicon atoms within the cation. Dicyanamide [N(CN)<sub>2</sub>]<sup>-</sup>, tetracyanoborate [B(CN)<sub>4</sub>]<sup>-</sup> and *bis*-(trifluoromethanesulfonyl)imide [NTf<sub>2</sub>]<sup>-</sup> were selected as anions due to differences in their size and rigidity. Argon absorption was measured in 9 ILs using a low-pressure **isochoric saturation method**, and the mole fraction  $\chi(\text{Ar})$  solubilities were used as probe for relative free volumes. In order to validate experimental results and explore argon solvation environment, **molecular dynamics** simulations were performed utilizing the recently developed CL & Pol polarizable force-field. [1]

Branching in the carbon atom chain leads to **significant increase in IL viscosity** compared to the linear counterparts, while silicon atom incorporation in their

isoelectronic analogues provided a **remarkable viscosity reduction**. Modelling of cavity size distribution via MD provided a set of argon solubility data that matched the order of experimental solubility measurements. Results of this study demonstrate the usefulness of **the methodology of probing and prediction of the free volume in ILs**, and shed light on the structural features leading to increased free volume and reduced IL viscosity.

**Acknowledgements.** EB acknowledges *PostDoc Latvia* for financial support (Grant 1.1.1.2/VIAA/3/19/549). KG, IV and MCG thank IDEX-LYON for financial support (PIA ANR-16-IDEX-0005), and GENCI-IDRIS (Grant 2020-A0090800609) and PSMN at ENS de Lyon for computational resources.

## References

- [1] Goloviznina, K.; Canongia Lopes, J. N.; Costa Gomes, M.; Pádua, A. A. H. *J. Chem. Theory Comput.*, **2019**, *15*, 5858–5871.



# A NEW FRONTIER FOR NON-DESTRUCTIVE SPATIAL ANALYSIS OF PHARMACEUTICAL SOLID DOSAGE FORMS: MICRO-SPATIALLY/SPATIALLY OFFSET LOW-FREQUENCY RAMAN SPECTROSCOPY

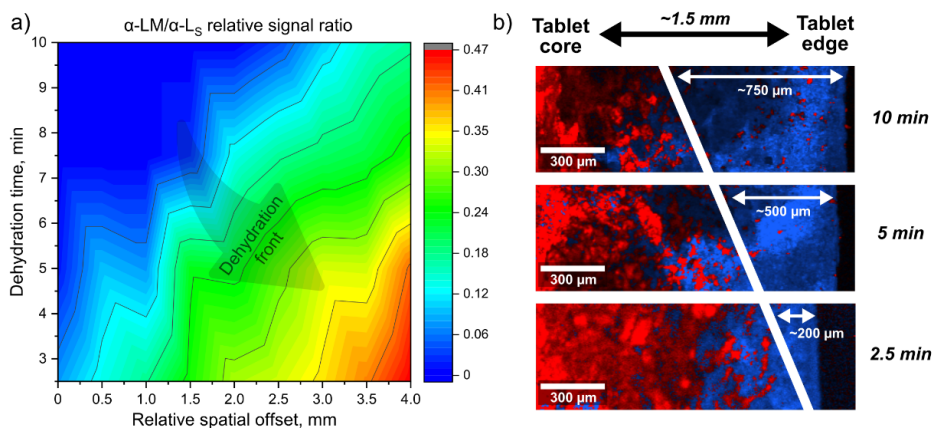
Kārlis Bērziņš, Sara J. Fraser-Miller, Keith C. Gordon

University of Otago, Department of Chemistry, Union Place West, 9016, Dunedin, New Zealand

E-mail: berka456@student.otago.ac.nz

A non-intrusive multi-dimensional analysis method can be useful in many pharmaceutical applications, especially for the analysis of solid dosage forms, where spatial information using conventional analytical methods can typically only be obtained after destructive manipulations with samples prior to or during the measurements. [1] This study demonstrated a new combination method of low-frequency and spatially offset Raman spectroscopy (SORS) method called spatially offset low-frequency Raman spectroscopy (SOLFERS) via the analysis of a number of model systems that showcase its capabilities for probing the layer (for example, coating) content/thickness characteristics as well as monitoring solid-state form transformations spatially.

For this purpose, celecoxib, lactose monohydrate ( $\alpha$ -LM) and its stable anhydrous form ( $\alpha$ -L<sub>s</sub>) as well as polyvinylpyrrolidone (PVP) were used as model compounds, and were incorporated in a variety of different multi-layer/multi-component tablets. Raman measurements were conducted using an in-house built system, and using both traditional SORS (SOLFERS) and micro-SORS (micro-SOLFERS) experimental arrangements. The associated data analysis was facilitated by the application of a variety of different chemometric techniques.



**Fig. 1.**  $\alpha$ -LM /  $\alpha$ -L<sub>s</sub> relative signal ratio projection from SOLFERS data collected at different time-points after isothermal dehydration of  $\alpha$ -LM tablets at 160 °C; (b) TrueComponent® (MCR-like) analysis of Raman microscopy data of the selected areas within the cross-sections of the same tablets (red color denotes  $\alpha$ -LM, whereas blue color –  $\alpha$ -L<sub>s</sub>)

In all the explored scenarios, micro-SOLFRS/SOLFRS proved superior to the more commonly used mid-frequency (fingerprint) Raman region that is used in SORS, yielding better Raman signals from the subsurface. This aspect, for example, not only enabled a more accurate determination of surface layer (i.e., coating) thickness characteristics, but also allowed to probe much deeper subsurface areas.

## References

- [1] Bērziņš, K.; Fraser-Miller, S. J.; Gordon, K. C. *Anal Chem.*, **2021**, 93, 3698–3705.

# EXPLORING ASPARTIC PROTEASE INHIBITOR BINDING TO DESIGN SELECTIVE ANTIMALARIALS

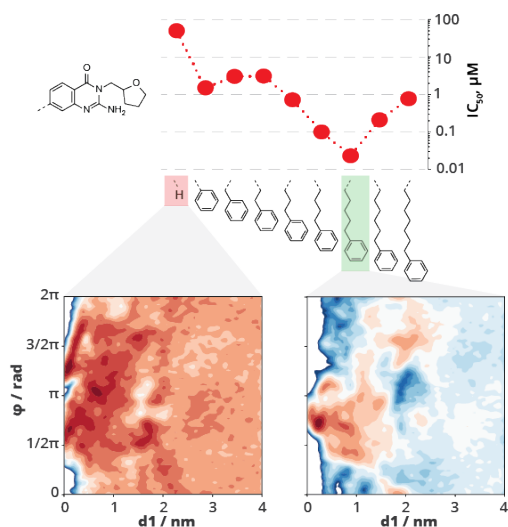
Raitis Bobrovs<sup>1</sup>, Emils Edgars Basens<sup>1</sup>, Laura Drunka<sup>1</sup>, Iveta Kanepe<sup>1</sup>, Sofija Matisone<sup>1</sup>, Karlis Kristofers Velins<sup>1</sup>, Victor Andrianov<sup>1</sup>, Gundars Leitis<sup>1</sup>, Diana Zelencova-Gopejenko<sup>1</sup>, Dace Rasina<sup>1</sup>, Aigars Jirgensons<sup>1</sup> and Kristaps Jaudzems<sup>1, 2</sup>

<sup>1</sup> Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia

<sup>2</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

E-mail: raitis.bobrovs@osi.lv

Selectivity is a major issue in the development of drugs targeting pathogen aspartic proteases. Here we explore the selectivity determining factors by studying specifically designed malaria aspartic protease (plasmepsin) open-flap inhibitors. 2-Aminoquinazolin-4(3H)-one based plasmepsin inhibitors with various flap pocket substituents are synthesized and their potencies against several aspartic proteases are determined. Metadynamics simulations are used to uncover the complex binding/unbinding pathways of these inhibitors, and describe the critical transition states in atomistic resolution. Our findings demonstrate that plasmepsin inhibitor selectivity can be achieved by targeting the flap loop with hydrophobic substituents that enable ligand binding under the flap loop, as such behaviour is not observed for several other aspartic proteases. The ability to estimate compound selectivity before they are synthesized is of great importance in drug design, therefore, we expect that our approach will be useful in selective inhibitor design not only against aspartic proteases, but other enzyme classes as well.



**Fig. 1.** Binding free energy surfaces of 2-aminoquinazolin-4(3H)-ones designed, synthesized and enzymatically tested for potency against plasmepsin II

**Acknowledgements.** This work was supported by the Latvian Council of Science, project No. lzp-2020/2-0012. RB acknowledges European Regional Development Fund project No. 1.1.1.2/VIAA/2/18/379 for financial support. Professor Emilio Parisini and Teodors Pantelejevs are acknowledged for their help with X-ray diffraction data acquisition and crystal structure refinement. We acknowledge Swiss Light Source for access to macromolecular crystallography beam line PX3 (proposal 20201060). Calculations were partly performed on Riga Technical University (RTU) High Performance Computing (HPC) Centre facilities.

# THERMAL ANALYSIS AND IR SPECTROSCOPY USAGE TO DETERMINE THE DEGREE OF SULFONATION OF SPEEK

Dmitrijs Bogdanovs<sup>2</sup>, Einārs Sprūģis<sup>2</sup>, Guntars Vaivars<sup>1,2</sup>

<sup>1</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

<sup>2</sup> Institute of Solid State Physics, University of Latvia, Ķengaraga iela 8, Riga, Latvia  
E-mail: bogdanovsmitrij@gmail.com

As the use of ion exchange membranes increases, so does the need to improve them. SPEEK membranes are described using their sulfonation degree (DS) that is directly related to other membrane parameters. The degree of sulfonation is defined as the percentage of re-sulfonated SPEEK units [1]. Therefore, it is necessary to find a cheap, easy-to-perform and accurate method for testing DS.

The examination of sulfonated polyether ether ketone membranes and ionic liquids was performed using thermogravimetry and Fourier transform infrared spectroscopy methods at the Institute of Solid Phase Physics. Previously formed membranes and ionic solutions were heated in the thermogravimeter LABSYS Evo. The evaporated portion released during the experiment was transferred to an infrared spectrophotometer for analysis using argon as a carrier gas.

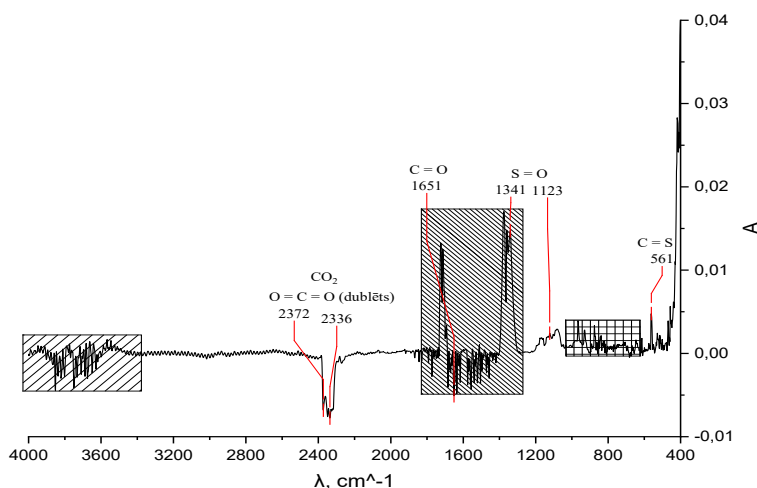


Fig. 1. Adjusted FTIR graph for SPEEK membrane

The preliminary results show that all the SPEEK membranes had some amount of water and organic matter pollution compared to freshly made SPEEK membranes [1]. SPEEK membranes DS can only be compared to other similar graphs to approximate the degree of sulfonation.

## References

- [1] El-Araby, R.; Attia, N. K.; Eldiwani, G.; Khafagi, M. G.; Sobhi, S.; Mostafa, T. *World Appl. Sci. J.*, 2014, 32, 2239–2244.

# MECHANOCHEMICAL PREPARATION OF CRYSTAL FORMS OF SELECTED PHARMACEUTICAL SUBSTANCES

Zane Čerpakovska, Artis Kons, Agris Bērziņš

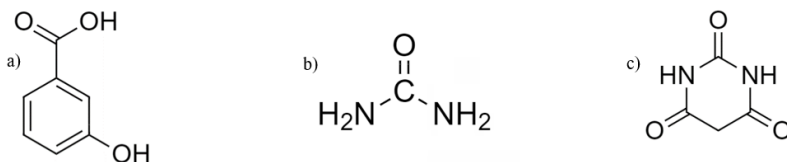
University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

E-mail: [zc13011@edu.lu.lv](mailto:zc13011@edu.lu.lv)

Drugs may exhibit different solid forms, and this diversity can often modify their physicochemical and bioabsorption properties. Pharmaceuticals can exist either as single component phases with different crystal structures (polymorphs), and also as multicomponent phases such as solvates, co-crystals, and salts. Moreover, each of these multicomponent phases can form different polymorphs. It is reported that approximately 80% of all drug molecules exhibit polymorphism [1].

The most common method used to control polymorphism is crystallization. An alternative to the most commonly used solvent crystallization is a mechanochemical treatment of a crystalline substance or a mixture of more than one substance. Mechanochemistry is defined as chemical synthesis induced by external mechanical energy, such as grinding two solids using a mortar-and-pestle, ball-mill, or shaker [2]. Such reactions are classified as Green Chemistry synthesis, prioritizing high yields, mild conditions and low to no use of solvents [3].

To date, three polymorphic forms of 3-hydroxybenzoic acid (3OHBA, Fig. 1a) have been described [4]. Similarly, crystal structures of three polymorphs have been found for co-crystal formed between urea (Fig. 1b) and barbituric acid (BA, Fig. 1c) [5].



**Fig. 1.** a) Molecular structure of 3OHBA, b) Molecular structure of urea, c) Molecular structure of BA

In a research of solid form landscape of 3-hydroxybenzoic acid two solvates and one salt not previously described in the literature were obtained mechanochemically. These phases were also obtained by a simple evaporative crystallization method. It was demonstrated that polymorphic forms of urea-barbituric acid co-crystal can be obtained not only by the crystallization from non-aqueous solvents as described in the literature, but also mechanochemically by grinding in presence of a few drops of water. This preparation procedure corresponds to the direction of green chemistry, and further research has the potential to identify an industrially useful and cost-effective preparation procedure of these phases.

## References

- [1] Solares-Briones, M.; Coyote-Dotor, G.; Páez-Franco, J. C.; Zermeño-Ortega, M. R.; de la O Contreras, C. M.; Canseco-González, D.; Germán-Acacio, J. M. *Pharmaceutics*, **2021**, *13*(6), 790.
- [2] Stojakovic, J.; MacGillivray, L. R. Cocrystals and Templates to Control Solid-State [2+2] Photodimerizations. *Comprehensive Supramolecular Chemistry II*, **2017**, 73–87.
- [3] Varma, R. S. *ACS Sustain. Chem.Eng.*, **2016**, *4*(11), 5866–5878.
- [4] Braun, D. E. *CrystEngComm.*, **2021**, *23*(13), 2513–2519.
- [5] Gryl, M.; Krawczuk, A.; Stadnicka, K. *Acta Crystallogr. B Struct. Sci.*, **2008**, *64*(5), 623–632.

# PLASMEPSIN II LABELING STRATEGIES TO STUDY CONFORMATIONAL CHANGES OF BINDING SITE WITH NMR SPECTROSCOPY

Laura Drunka<sup>1,2</sup>, Raitis Bobrovs<sup>1</sup>

<sup>1</sup> Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia

<sup>2</sup> Riga Technical University, Faculty of Materials Science and Applied Chemistry, Paula Valdena iela 3/7, Riga, Latvia

E-mail: laura.drunka@osi.lv

Malaria infection in humans is caused by *Plasmodium Falciparum* parasite. *P. Falciparum* aspartic proteases (plasmepsins) are responsible for catalytic hemoglobin degradation and thus are being investigated as potential drug targets. Plasmepsins, however, share high structural similarity with human aspartic proteases, emphasizing the need for selective inhibitors. Selectivity of several known plasmepsin inhibitors is attributed to unusual binding under the flap loop [1]. One of the methods that can be used to characterize binding site dynamics upon inhibitor binding is NMR spectroscopy, however, due to large plasmepsin II size, selective protein labeling is required. Here we present two selective protein labeling strategies.

Substitution of certain amino acids with their fluorinated analogues can be exploited to study conformational changes with <sup>19</sup>F NMR spectroscopy. In this study tryptophan was chosen as amino acid of interest due to its position near the binding site and low number of residues. Labeled protein was obtained using biosynthetic amino acid incorporation [2].

Second method used was spin labeling with a molecule containing nitroxide moiety. Paramagnetic groups such as MTSL (*S*-(1-oxyl-2,2,5,5-tetramethyl-2,5-dihydro-1H-pyrrol-3-yl)methyl methanesulfonothioate) increase relaxation rate of nearby atoms, allowing to estimate inter-atomic distances up to 25 Å, and, thus, exact position of inhibitor in the binding site. MTSL label was attached to cysteine residue that was introduced in the flap loop using site-directed mutagenesis [3].

Obtained NMR spectra show that both labels have been successfully incorporated in plasmepsin II molecule, however, protein preparation, yields and recording conditions of NMR spectra still need to be optimized in order to apply these methods to protein dynamics studies.

**Acknowledgements.** This work was supported by the Latvian Council of Science, project No. lzp-2020/2-0012. RB acknowledges European Regional Development Fund project No. 1.1.1.2/VIAA/2/18/379 for financial support.

## References

- [1] Bobrovs, R.; Jaudzems, K.; Jirgensons, A. *J. Med. Chem.*, **2019**, 62(20), 8931–8950.
- [2] Kitevski-LeBlanc, J. L.; Prosser, R. S. *Prog. Nucl. Magn. Reson. Spectrosc.*, **2012**, 62, 1–33.
- [3] Sjodt, M.; Clubb, R. T. *Bio-Protoc.*, **2017**, 7(7), 1–14.



# VITAMIN B<sub>12</sub> BLOOD LEVEL VARIATION WITH THE AGE OF PATIENTS

Didzis Gavars<sup>1,2</sup>, Agris Auce<sup>3</sup>, Eriks Tauckels<sup>1</sup>, Ilze Lindenberga<sup>1</sup>, Dmitrijs Perminovs<sup>1,3</sup>, Anna Inese Tutane<sup>1,2</sup>, Agnese Miķelsone<sup>2</sup>

<sup>1</sup> Egils Gulbis Laboratory, Riga, Latvia

<sup>2</sup> Riga Stradiņš University, Riga, Latvia

<sup>3</sup> Institute of Chemical Physics, University of Latvia, Jelgavas iela 1, Riga, Latvia,  
E-mail: agris.auce@lu.lv

**Introduction.** It has been shown that determination of reference intervals (RI) using accumulated general patient data can be a cost effective alternative [3] to special research following C28-A3 guidelines [1].

There are some reports on B12 RI for different ethnicities [2]. There is little and somewhat contradictory information about the B12 RI for different age groups and sexes. In this work the method of calculation of B12 reference intervals from large number of general patient data described by Gavars et al. [3] was used to calculate B12 RI intervals for different sexes and age groups.

**Materials and methods.** Results of 172597 B12 tests accumulated at EGL from 1<sup>st</sup> of January 2018 till 21<sup>st</sup> of November 2021 were used. B12 values were obtained using standard clinical laboratory technique and procedure. Data set consisted of 150 to 400 test results for each one year age interval at the age of 1 to 10 years, and more than 1000 test results for each one year age interval at the ages over 21 years. Mean B12 value and RI was calculated for each age group by 2 years steps. RI interval was calculated by fitting patient density distribution to Gaussian distribution and using only one third of patient data – only those patient data that were close to the mean B12 value were used in the fitting procedure.

**Results.** High quality B12 mean value and RI data were obtained for each age group and both sexes. Results show distinct variation of B12 mean value with the age of patients. For children B12 mean value raises from 449 pg/l at the age of 1 year to maximum of 665 pg/l at 5–7 years of age. Then the B12 mean value declines to minimum of 410 pg/l at the age of 20 years. From age 23 to 35 the mean B12 value gradually increases to 470 pg/l and stays almost constant during the rest of the lifespan. The calculated reference interval follows the same trend. The difference between calculated high and low RI starts to increase at older age, starting at approximately 60 years of age.

**Conclusion.** A systematic variation of B12 blood level values with the age was observed with B12 blood level peaking at the age of 5–7 years. Lowest B12 blood level was observed at the age of 17–23 years.

## References

- [1] Gary, L. et al. *Clinical and Laboratory Standards Institute*, 2010, 28, 12.
- [2] Jiang, W. et al. *J. Clin. Lab. Anal.*, 2020, 34, 5, 1–6.
- [3] Gavars, D. et al. *submitted to Proceedings of the Latvian Academy of Sciences. Section B: Natural, Exact, and Applied Sciences.*

# CYCLODEXTRIN BASED METAL ORGANIC FRAMEWORK CRYSTALLIZATION AND EVALUATION AS POTENTIAL DRUG CARRIER

**Kristīne Krūkle-Bērziņa, Anatolijs Mishnev, Kirills Šubins**

*Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia  
E-mail: kkberzina@osi.lv*

Metal-organic frameworks (MOFs) have been known for decades, and they continuously have gained interest because of their application potential increasing in the various fields – pharmacy, medicine, technology etc [1]. MOFs porous architecture and adjustable properties allow them to be considered as promising drug carriers. Modification of the properties of an existing active pharmaceutical ingredient (API) without changing its biological role can be much faster and more effective [2].

In this study different cyclodextrin based MOFs were crystallized using various methods and characterized by X-ray methods. At the results we obtained new crystal structures for  $\alpha$ -CD-K MOF in crystallization using vapor diffusion method. New crystal structure for  $\beta$ -CD-K MOF using solvent exchange method. New crystal phase for  $\gamma$ -CD-K using fast crystallization. All crystal forms were compared and evaluated as potential drug carriers.

**Acknowledgements.** Project is co-financed by European Regional Development Fund within the Activity 1.1.1.2 “Post-doctoral Research Aid”. Research application No. 1.1.1.2/VIAA/3/19/583, “Application of metal-organic frameworks as potential carriers of active pharmaceutical ingredients”.

## References

- [1] Rajkumar, T.; Kukkar, D.; Kim, K. H.; Sohn, J. R.; and Deep, A. *J. Ind. Eng. Chem.*, **2019**, 72, 50–66.
- [2] Domingos, S.; André, V.; Quaresma, S.; Martins, I. C. B.; Minas da Piedade, M. F.; Duarte, M. T. *J. Pharm. Pharmacol.*, **2015**, 67, 830–846.

# USE OF SELECTIVE MOF FORMATION FOR SEPARATION OF $\alpha$ -, $\beta$ - AND $\gamma$ -CYCLODEXTRINS

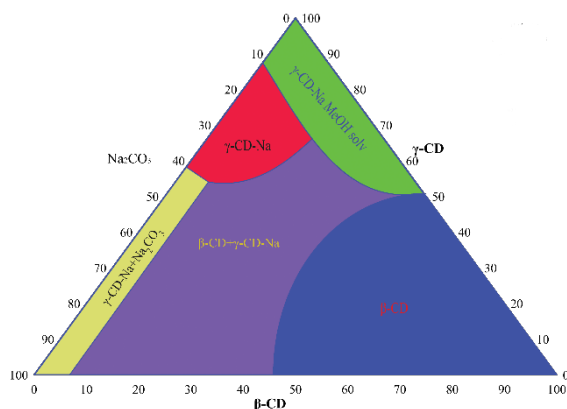
Kristīne Krūkle-Bērziņa, Kirills Šubins, Sergejs Beļakovs

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Rīga, Latvia

E-mail: [kkberzina@osi.lv](mailto:kkberzina@osi.lv)

Cyclodextrins (CD's) are cyclic oligosaccharides widely used in pharmaceutical, food and cosmetic industries as excipients and stabilizers. They are produced by enzymatic transformation of starch, obtained from renewable green sources (potato, corn, etc.). This process is unselective and typically leads to a formation of a mixture of CD's with various numbers of glucose subunits in the cycle (6 for  $\alpha$ , 7 for  $\beta$  and 8 for  $\gamma$ ). One of approaches to their separation is a selective formation of a metal-organic framework (MOF), where a CD molecule serves as a ligand [1].

In order to create an efficient, sustainable and scalable separation process behavior of various CD mixtures was investigated under MOF crystallization conditions. In all cases crystallization of MOF was carried out in the presence of  $\text{Na}_2\text{CO}_3$  in aq. MeOH. The precipitated material was investigated by powder X-ray diffractometry and obtained results are summarized on ternary diagram (Fig. 1).



**Fig. 1.** Ternary diagram of crystalline products obtained from various compositions of  $\beta$ -CD,  $\gamma$ -CD and  $\text{Na}_2\text{CO}_3$  with different mass ratios (border lines between phases are put for clarity, they are not accurate)

$\alpha$ -CD remained in solution in a wide range of concentrations (10–90 mass% from the total mass of CD's). It was excluded and a variable amount of  $\text{Na}_2\text{CO}_3$  was included in the diagram instead. The least soluble  $\beta$ -CD dominates in the solid phase when its amount in solution is  $> 50$  mass%; while in the 20–50 mass% range a mixture  $\beta$ -CD +  $\gamma$ -CD-Na MOF is precipitated. Low concentrations of  $\text{Na}_2\text{CO}_3$  ( $< 10$  mass%) lead to precipitation of  $\gamma$ -CD $\cdot$ MeOH with a low yield.

At a higher concentration of  $\text{Na}_2\text{CO}_3$  (> 40 mass%)  $\gamma$ -CD-Na is formed, but it is contaminated with  $\text{Na}_2\text{CO}_3$ . The most efficient crystallization of pure  $\gamma$ -CD-Na was achieved in 10–40 mass% range of  $\text{Na}_2\text{CO}_3$  with < 20 mass% of  $\beta$ -CD.

**Acknowledgements.** This research was supported by a project “Development of innovative face cosmetics with controlled release of active ingredients by use of Metal Organic Frameworks or Cocrystals” (ERAF project number 1.1.1.1/18/A/176).

## References

[1] Limketkai, B. N.; Botros, Y. Y. *Methods to Isolate Cyclodextrins*. US2017058306A1, 02.03.2017.

# MASS-SEPARATION OF $^{43,44,47}\text{Sc}$ RADIONUCLIDES FROM IRRADIATED NATURAL Ti TARGETS AT THE CERN-MEDICIS FACILITY

Edgars Mamis<sup>1,2</sup>, Elīna Pajuste<sup>1</sup>, Thierry Stora<sup>2</sup>, Sebastian Rothe<sup>2</sup>, Eric Chevallay<sup>2</sup>, Charlotte Duchemin<sup>2</sup>, Maija Radziņa<sup>3</sup>

<sup>1</sup> Institute of Chemical Physics, University of Latvia, Jelgavas iela 1, Rīga, Latvia

<sup>2</sup> CERN, Esplanade des Particules 1, Geneva, Switzerland

<sup>3</sup> University of Latvia, Faculty of Medicine, Jelgavas iela 3, Rīga, Latvia

E-mail: edgars.mamis@lu.lv; edgars.mamis@cern.ch

Medical radionuclides as  $^{43,44g,44m,47}\text{Sc}$  are very promising in “matched theranostic pair” radiopharmaceutical development for cancer treatment. Use of natural titanium as target material for production of  $^{43,44g,44m,47}\text{Sc}$  radionuclides is favorable in terms of cost and the wide availability of target material, in contrast of using low abundant enriched Ca targets. We report here the recent studies, development, production and extraction of scandium radionuclides from irradiated thick natural titanium targets at MEDICIS at CERN.

In this work, natural titanium targets were irradiated at the MEDICIS target irradiation station with 1.4 GeV protons delivered by the CERN Proton Synchrotron Booster (PSB). Although nuclear reaction cross-sections of  $^{43,44g,44m,47}\text{Sc}$  for nat-Ti(p,x) confirm that enough production yield can be achieved to synthesize radio-bioconjugates for imaging studies [1], the presence of contaminant isotopes such as long lived Sc-46 in radiopharmaceutical precursor is not acceptable. To overcome this obstacle, Sc radionuclide purification step, according to their mass using the Isotope Separator OnLine (ISOL) technique and the MEDICIS mass-separator was introduced. The separation of Sc and Ti as elemental radioactive beams is challenging due to their reactive nature, high boiling points and low vapour pressure. Therefore, formation of more volatile molecules, extraction and collection of desired radionuclides were introduced.

Low intensity radioactive  $\text{Sc}^+$  and  $\text{ScF}^+$  beams with W surface ion source have been reported at ISOLDE [2]. In this work,  $\text{ScF}_x^+$  ( $x = 1-2$ ) and  $\text{natTiF}_y^+$  ( $y = 1-3$ ) molecular beams in natural Ti target material and natural Ta target structure ambience have been obtained with a Versatile Arc Discharge Ion Source (VADIS). Also, optimal radionuclide extraction and separator operation parameters were yet to be determined.

We hereby report our results on the positive effect of volatile rare earth and refractory metal molecular beam formation for isotopically pure  $^{44,47}\text{Sc}$  extraction and mass-separation. Although ISOL and mass-separation is mandatory, chemical separation step on the collected elements must be done to separate from presence of isobars in the collection foil.

## References

- [1] Shahid, M.; Kim, K.; Kim, G.; Naik, H. *J. Radioanal. Nucl. Chem.*, **2018**, 318, 2049–2057.
- [2] Eder, R.; Grawe, H.; Hageb, E.; Hoff, P.; Kugler, E.; Ravn, H. L.; Steffensen, K. *Nucl. Instrum. Methods Phys. Res.*, **1992**, B-62, 535–540.

# MIRCOCALORIMETER PERFORMANCE DETERMINATION AND STABILITY DETERMINATION OF NITROCELLULOSE-BASED SUBSTANCES AND THEIR COMPARISON WITH CHROMATOGRAPHIC RESULTS

Kaspars Meijers, Pēteris Mekšs

University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia  
E-mail: meijers.kaspars@gmail.com

Nitrocellulose-based substances are dangerous because of their instability; therefore, stabilizers are added, but due constant chemical reactions, they are depleted, that's why for safety of everyone involved, nitrocellulose-based substance stability must be tested. In the last few years Latvia started to test its own munition on chemical stability, which was limited to chromatographic methods, but now an opportunity arose to test it with microcalorimetry and in addition compare the obtained results between two methods.

Microcalorimeter performance was determined via two methods, one being internal test and the second one being biphenyl test. Internal test results were in agreement with instrument requirements, whereas biphenyl test showed slight deviation from requirements for one of six microcalorimeters at 1,8%.

Analysed munition samples, delivered by Latvian National Armed Forces, contained two different stabilisers. First stabiliser was diphenylamine, samples with this stabiliser showed that it would be stable for up to ten years at 25 °C, but one of the samples was nearing its limits. Another stabiliser was centralite I or ethylcentralite. Samples containing centralite I displayed almost no deviation from the baseline, therefore it can be stored and safely used.

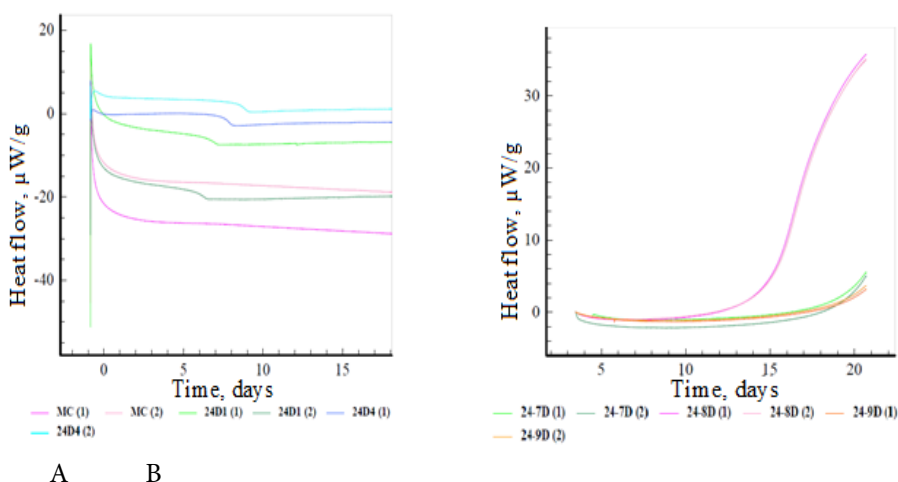


Fig. 1. Obtained plots for heat flow against time. (a) – diphenylamine; (b) – centralite I

The obtained results with chromatographic methods displayed similar results, samples containing diphenylamine displayed slight decrease in stabiliser content after aging, where in one of the samples the decrease was quite extensive. Samples with centralite I displayed almost no decrease in stabiliser content after aging, which was around 0,1%.

# IMPACT OF PHYSICAL PRETREATMENT ON THERMAL PROPERTIES OF COURSED SHEEP WOOL FIBERS

Jānis Nesenbergs<sup>1</sup>, Taisija Gricenko<sup>2,3</sup>, Līga Avotiņa<sup>2</sup>, Artūrs Zariņš<sup>2,4</sup>,

Mihails Haļitovs<sup>2,5</sup>, Gunta Ķizāne<sup>2</sup>

<sup>1</sup> Faculty of Materials Science and Applied Chemistry, Riga Technical University, Paula Valdena iela 3/7, Riga, Latvia

<sup>2</sup> Institute of Chemical Physics, University of Latvia, Jelgavas iela 1, Riga, Latvia

<sup>3</sup> Faculty of Chemistry, University of Latvia, Jelgavas iela 1, Riga, Latvia

<sup>4</sup> Faculty of Natural Sciences and Mathematics, Daugavpils University, Daugavpils, Latvia

<sup>5</sup> Department of Human Physiology and Biochemistry, Riga Stradins University, Riga, Latvia

E-mail: liga.avotina@lu.lv

Sheep breeding in Latvia in the last decade is stabilized and continues to develop. Since sheep breeding includes producing of wool, it is important for fabrication of textiles and thermoinsulators. However, annually tons of wool fibers, that do not fit to requirements to be used in textile industry, remain as residues. Such wool can be used as sorbent [1] or convert in activated carbon [2] and use in air filters. In order to increase the area of applications, various treatment methods can be applied, such as chemical [3] or radiation modification [4].

In the present research impact of physical treatment is investigated. Coursed sheep wool was felted (Ltd. Sunakstes Vilnas nams). Non-felted and felted wool was held under various conditions: exposure to light, decreased temperature, moisture, etc. Non-exposed and exposed wool fibers analyzed using thermogravimetry/differential thermal analysis (TG/DTA) method combined with Fourier transform infrared (FTIR) spectrometry. Analysis performed up to 1000 °C. Volatile compounds, that are released during heating process, are analysed by registering FTIR spectra with Bruker Vertex 70v equipped with a gas cell and liquid nitrogen – HgCdTe detector.

The obtained results show that coursed sheep wool has three main mass decrease steps, first related with water vapor release, in FTIR spectra are characteristic peaks in ranges of 1500–1700 cm<sup>-1</sup> and 3000–3700 cm<sup>-1</sup>. Second step is followed by occurring of number of peaks in the FTIR spectra such as at 2850 and 2920 cm<sup>-1</sup> related to -CH<sub>2</sub> and -CH<sub>3</sub> groups, CO [5] with maximal intensities around 2180 and 2120 cm<sup>-1</sup>, CO<sub>2</sub> centered around 675, 2345 and 3580–3740 cm<sup>-1</sup> and others. Third main mass loss is followed by release of CO<sub>2</sub>. TG data show that up to 400 °C the decomposition pattern is similar for both felted and non-felted wool. The obtained results will be used for developing recommendations for producing activated carbon from biofibers.

**Acknowledgements.** Research is performed within the frames of ERDF project No: 1.1.1.1./20/A/155 “Development of novel and innovative composite materials with enhanced sorption properties from renewable biological natural resources available in the Republic of Latvia for commercial air purification filtration systems”.



## References

- [1] Enkhzaya, S.; Shiomori, K.; Oyuntsetseg, B. *J. Env. Chem. Eng.*, **2020**, *8*, 5, 104021.
- [3] Pina, A.; Tancredi, N.; Baldan, M.; Marcuzzo, J.; Amaya, A. *MRS Adv.*, **2018**, 1–12.
- [4] Seiko, J.; Sabu, T.; Jibin, K. P.; Sisanth, K. S.; Kadam, V.; Shakyawar, D. B. *Ind. Cr. and Prod.*, **2022**, *177*, 114489.
- [5] Braniša, J.; Jomová, K.; Lapčík, L.; Porubská, M. *Polym. Testing*, **2021**, *99*, 107191.
- [6] Brebu, M.; Spiridon, I. *J. of An. and App. Pyrol.*, **2011**, *91(2)*, 288–295.

# METALLIC NANOPARTICLE DISPERSIONS FOR CONDUCTING INK PREPARATION

**Aleksandrs Novikovs, Boriss Poļakovs**

*Institute of Solid State Physics, University of Latvia, Kengaraga iela 8, Riga, Latvia*

*E-mail: aleksandrs.novikovs@cfi.lu.lv*

The aim of this research is to prepare conducting nanoparticle inks, such that it would be possible to print electrical components using a functional ink-jet printer.

Relevance of the topic is related to preparation of cheap and wearable electrical circuits, preparation of RFID antennas, preparation of sensors.

Following nanoparticles for inks were prepared: silver spherical nanoparticles in water, silver triangle nanoprisms in water, copper spherical nanoparticles in hexane, copper spherical nanoparticles with silver shell in hexane and nickel spherical nanoparticles in hexane. Prepared dispersions were characterized with SEM or TEM microscopy, UV-Vis spectroscopic methods, XRD, DLS, electrical conductivity was estimated and aggregation stability. In all dispersions nanoparticle size is less than 100 nm. All samples were sintered at 150 °C, 200 °C, 250 °C, 300 °C temperatures and after that those samples were analyzed with SEM. It can be concluded, that it is possible to formulate inks using these particles, and it may be possible to use these to print electrical components.

**Acknowledgements.** The financial support of ERAF project Nr. 1.1.1.1/20/A/060 is greatly acknowledged.

# FINE-TUNING SOLID STATE LUMINESCENCE PROPERTIES OF MOLECULAR CRYSTALS VIA SOLID SOLUTION FORMATION

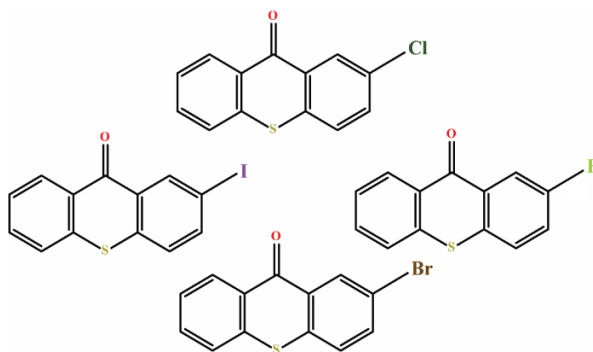
Kristaps Saršūns, Agris Bērziņš, Toms Reķis

University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

E-mail: kristaps.sarsuns@lu.lv

Approaches and tools of crystal engineering is developed to allow employing the knowledge of intermolecular interaction preferences to predict crystal structure formation and therefore crystal properties. For example, solid solutions, for which the component ratios can be varied in continuum [1]. Along with the composition, also properties of solid solutions are modulated. Therefore, they hold a potential for tuning molecular crystal material properties in a smooth fashion. The question, however, is whether the response of a wanted property is sensitive enough to the varying component ratio. The properties may include solid-state luminescence and phosphorescence properties [2].

In this study we explored the solid solution formation between thioxanthone halogenated derivatives (Fig. 1., TX-R, R = Cl, F, Br, I). The compounds have been selected based on reported room-temperature solid-state luminescence phenomena [3] and chemically similar structures, in which the different atom (R) may not significantly affect the dominant intermolecular interactions.



**Fig. 1.** Molecular structures of thioxanthone halogenated derivatives

Solid solutions have been identified and characterized using powder X-ray diffraction and thermal methods of analysis. Their composition limits are summarized in respective two component phase diagrams. Photoluminescence spectra of all crystalline phases in powder form were recorded to see how they change with respect to those of the pure substances known from the literature [3]. As a result, this confirmed that fine-tuning solid state luminescence properties of molecular crystals can be modulated via solid solution formation.

## References

- [1] Lusi, M. *Cryst. Growth Des.*, **2018**, *18*(6), 3704–3712.
- [2] Saršūns, K.; Bērziņš, A.; Reķis, T. *Cryst. Growth Des.*, **2020**, *20*(12), 7997–8004.
- [3] Wen, Y.; Liu, H.; Zhang, S.; Gao, Y.; Yan, Y.; Yang, B. *J. Mater. Chem. C*, **2019**, *7*, 12502–12508.

# CONTROL POSSIBILITIES OF 2,6-DIMETHOXY-BENZOIC ACID CONFORMATIONAL POLYMORPHISM USING CRYSTALLIZATION ADDITIVES

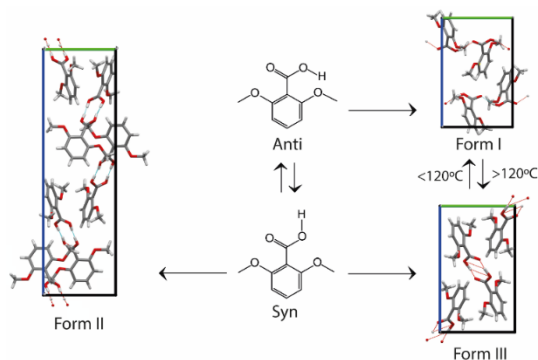
Aina Semjonova, Agris Bērziņš

University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

E-mail: aina.semjonova@lu.lv

Active pharmaceutical ingredients (APIs) can have different physical properties (e.g., solubility [1] and bioavailability) depending on polymorph form. Many APIs have low solubility in water. Crystallization of metastable form can enhance solubility and bioavailability [2]. Unfortunately, their crystallization can be complicated due to concomitant crystallization with a stable form [3].

In this study, 2,6-dimethoxybenzoic acid (2,6-MeOBA) was used as a model substance to investigate the additive crystallization control approach. 2,6-MeOBA exists as three polymorphs. Form I form has a carboxylic group in *anti*-conformation, whereas forms II and III are *syn*-conformation [4, 5] (see Fig. 1).



**Fig. 1.** Relationships with 2,6-MeOBA conformations and polymorphs.  
The connection between forms I and III is proven in this study

In the study, two of 2,6-MeOBA polymorphs were characterized by thermal analysis and thermodynamical stability was determined. 2,6-MeOBA was crystallized under different conditions. Water was selected for additive screening. Different molecular compounds with divergent intermolecular interaction possibilities were used as additives. The solid forms obtained in crystallization were characterized with powder X-ray diffraction.

Forms I and III are enantiotropic related. Hydroxypropyl cellulose and polyethylene glycol showed the potential to favor the formation of form III by crystallizing from water.

**Acknowledgements.** This work was supported within the Project identification No. 8.2.2.0/20/I/006.

## References

- [1] Pudipeddi, M.; Serajuddin, A. T. M. *J. Pharm. Sci.*, **2005**, *94*(5), 929–939.
- [2] Censi, R.; Martino, P. di. *Molecules*, **2015**, *20*, 18759–18776.
- [3] Tang, W.; Sima, A. D.; Gong, J.; Wang, J.; Li, T. *Cryst. Growth Des.*, **2020**, *20*(3), 1779–1788.
- [4] Portalone, G. *Acta Cryst. E* **2020**, *76* (12), 1823–1826.
- [5] Pal, R. et al. *J. Mol. Struct.*, **2020**, *1221*.

# X-RAY INDUCED DEFECTS IN LITHIUM ORTHOSILICATE AND LITHIUM METATITANATE CERAMICS PREPARED USING SOLID STATE SYNTHESIS METHOD

Madara Tomele<sup>1</sup>, Mareks Seņko<sup>1</sup>, Artūrs Zariņš<sup>1,2</sup>, Aleksejs Zolotarjovs<sup>3</sup>, Larisa Baumanė<sup>1,4</sup>, Gunta Ķizāne<sup>1</sup>

<sup>1</sup> University of Latvia, Institute of Chemical Physics, Jelgavas iela 1, Riga, Latvia

<sup>2</sup> Daugavpils University, Faculty of Natural Science and Mathematics, Parades iela 1A, Daugavpils, Latvia

<sup>3</sup> Institute of Solid State Physics, University of Latvia, Kengaraga iela 8, Riga, Latvia

<sup>4</sup> Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia, LV-1006

E-mail: madara.tomele@lu.lv

Lithium orthosilicate ( $\text{Li}_4\text{SiO}_4$ ) and lithium metatitanate ( $\text{Li}_2\text{TiO}_3$ ) for radiation-induced defect studies have been made using numerous methods including sol-gel, melt-spraying, drip-casting and solid-state reaction process in order to evaluate radiation stability of material for application as tritium breeding ceramics in future thermonuclear fusion reactors [1, 2]. Solid-state reaction process has many advantages, such as high yield and easy scalability [3], however, to confirm the radiation stability of the material synthesized using this method, the formation and accumulation of radiation-induced defect must be assessed.

In this study,  $\text{Li}_4\text{SiO}_4$ ,  $\text{Li}_4\text{SiO}_4$  with additions of  $\text{Li}_2\text{TiO}_3$ ,  $\text{Li}_2\text{TiO}_3$  powder samples obtained by solid-state synthesis route as well as mechanically mixed  $\text{Li}_4\text{SiO}_4$  and  $\text{Li}_2\text{TiO}_3$  powders were pressed into 10 mm pellets using manual hydraulic press at room temperature in air. Afterwards, the prepared pellets were irradiated with X-rays in high vacuum with pressure less than  $10^{-2}$  Pa at room temperature using an X-ray tube with wolfram anode. Operating parameters are as follows: 40 kV, 10 mA, irradiation time 15 minutes, and pressed pellet distance from X-ray tube is approx. 15 cm. The total concentration of formed and accumulated X-ray induced defects was assessed using electron paramagnetic resonance (EPR) spectrometry and thermally stimulated luminescence (TSL) technique.

The obtained results show that  $\text{Li}_2\text{TiO}_3$  had the lowest concentration of both EPR and TSL active X-ray induced defects. The concentration of TSL active defects in the  $\text{Li}_4\text{SiO}_4$  pellets with additions of  $\text{Li}_2\text{TiO}_3$  significantly exceeded those detected in  $\text{Li}_2\text{TiO}_3$ ,  $\text{Li}_4\text{SiO}_4$  pellets and in mechanically mixed  $\text{Li}_4\text{SiO}_4$  and  $\text{Li}_2\text{TiO}_3$  samples.

**Acknowledgements.** This study has been performed within the framework of the European Regional Development Fund (ERDF) project (application No. 1.1.1.2/VIAA/4/20/614).

## References

- [1] Stefanelli, E.; Vitolo, S.; Frano, R. Lo; Pesetti, A.; Aquaro, D.; Puccini, M. *Fusion Eng. Des.* **2022**, *175*, 113014.
- [2] Wang, Y.; Zhou, Q.; Xue, L.; Li, H.; Yan, Y. *J. Eur. Ceram. Soc.*, **2016**, *36*(16), 4107–4113.
- [3] Mandal, D.; Jadeja, M. C.; Sen, D.; Mazumder, S. *Fusion Eng. Des.*, **2016**, *112*, 613–620.

# APPROACH OF USING THE OPPOSITE CHIRALITY OF CROWN ETHER STATIONARY PHASES IN CHIRAL RECOGNITION OF TETRAPEPTIDE ENANTIOMERS

Toms Upmanis<sup>1,2</sup>, Helena Kažoka<sup>1</sup>

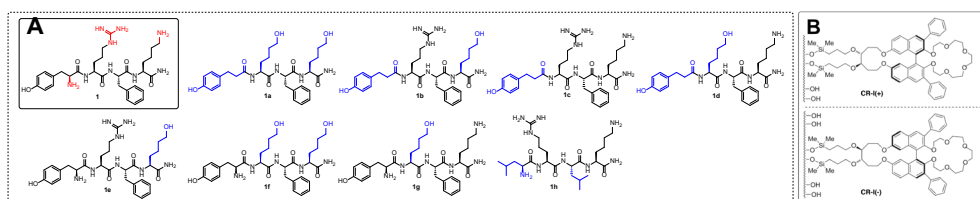
<sup>1</sup> Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia

<sup>2</sup> University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia

E-mail: upmanis@osi.lv

Crown ether chiral stationary phases have been successfully used for separating enantiomers of various racemic compounds containing primary amino groups. Although chiral recognition mechanism for crown-ether CSPs is generally understood, on a molecular level, the exact chiral recognition mechanisms for the resolution of short peptides, containing multiple amino moieties capable of binding to the crown ether selector, are still unclear [1].

A research of relationship between the peptide chemical structure and chiral chromatographic interactions was performed, by comparing the retention profiles of  $\mu$ -opioid receptor agonist tetrapeptide Tyr-Arg-Phe-Lys-NH<sub>2</sub> and eight its structural analogues (Fig. 1A), synthesized with the aim to selectively exclude interacting amino groups in tetrapeptide sequence on S- and R-(3,3'-diphenyl-1,1'-binaphthyl)-20-crown-6 stationary phases (CR-I (+) and (-) – Fig. 1B), in order to clarify, which of the potential interaction sites are responsible for chiral recognition in Tyr-Arg-Phe-Lys-NH<sub>2</sub> tetrapeptide.



**Fig. 1.** Structures of Tyr-Arg-Phe-Lys-NH<sub>2</sub>; its structural analogues – **A**;  
Structures of chiral stationary phases used in this study – **B**

It was established, that, under the same LC conditions, retention of tetrapeptide isomers, fixed in d-tyrosine position on CR-I (+) does not differ significantly from their corresponding lxxx enantiomer on CR-I (-) column and vice versa, demonstrating the capability of roughly estimating the retention times of the corresponding enantiomer.

By assuming, that only in case of stereoselective binding, retention times of single enantiomer on CR-I (+) and (-) columns, under the same chromatographic conditions, would differ from each other, this approach was used to study the retention behaviour of



eight tetrapeptide analogues. It was concluded that N-terminal  $\alpha$ -amino group in Tyr is responsible for chiral recognition of Tyr-Arg-Phe-Lys-NH<sub>2</sub>.

**Acknowledgements.** Studies were supported by Latvian Institute of Organic Synthesis internal grants (IG-2020-04; IG-2021-05).

## References

- [1] Upmanis, T.; Kažoka, H.; Arsenyan, P. *J. Chromatogr. A*, **2020**, *1622*, 461152.

# IDENTIFICATION OF THE MAIN DYESTUFFS PRESENT IN BARKS OF ALDERS, BIRCH, OAK AND ASPEN

**Valda Valkovska, Liāna Orola**

*University of Latvia, Faculty of Chemistry, Jelgavas iela 1, Riga, Latvia*  
*E-mail: valda.valkovska@lu.lv*

Substantial amounts of bark of forest trees are a by-product of wood processing, a major proportion of which is used for energy production. Nevertheless, it could also be a valuable source of tannins for use as natural colourants [1]. The barks of many trees are suitable sources of reddish-brown dyes. The most frequently mentioned brown-colouring barks were tannin-rich alder, oak, hemlock and maple [2]. Hydroxyl groups of tannins have capability form effective bonds with protein fibres and dyes to provide fix dyes by nonspecific bonding. Commonly, plant tannins (catechins, proanthocyanidins and polyphenols) have a strong affinity for proteins. Tannins together with metallic salt mordants form metal tannates, resulting in better colour fastness [2, 3].

The popular dye trees of Latvia summarized in the listing of plant dyes are: black alder (*Alnus glutinosa*), grey alder (*Alnus incana*), silver birch (*Betula pendula*), juniper (*Juniperus communis*), alder buckthorn (*Frangula alnus*), pedunculate oak (*Quercus robur*), bird cherry (*Padus avium*), aspen (*Populus tremula*), European crab apple (*Malus sylvestris*), ash (*Fraxinus excelsior*) [4, 5]. Dyeing process and materials used in farmsteads differed from the ones practiced by professional dyers. The peasants were employed birch bark in dyeing, mainly in light browns, blacks or other drab colours. The professional dyers obtained brighter tones and fastness of colours. Oaks were used by 18<sup>th</sup>- and 19<sup>th</sup>-century professional dyers, for they contained tannins and other dyeing agents which would give woollens stable colours [2].

The objective of the present study was to evaluate the extracts of black alder, grey alder, pedunculate oak, silver birch and aspen as natural textile dye. The dyeing solutions of barks were analysed by UPLC-DAD-MS. The preliminary results show that barks are a valuable source of tannins for use as natural colourants. Hydrolysable tannins (gallic acid, ellagic acid) and condensed tannins (catechin, procyanidins) were found in water extracts from tree barks.

## References

- [1] Fitz-Binder, C.; Bechtold, T. *Color. Technol.* **2018**, *135*, 32–39.
- [2] Adrosko, J. R. *Natural Dyes and Home Dyeing*. Dover Publications, New York, 1971.
- [3] Prabhu, K. H., Teli, M. D. *J. Saudi Chem. Soc.*, **2014**, *18*, 864–872.
- [4] Karlsona, A. *The Journal of the Institute of Latvian History*, **2018**, *2*, 62–81.
- [5] Slava, M. *Archaeology and ethnography*, **1966**, *7*, 27–31.

# **Section of Organic Chemistry**

# PLENARY LECTURES

## ELECTROCHEMICAL GENERATION OF HYPERVALENT BROMINE(III) COMPOUNDS

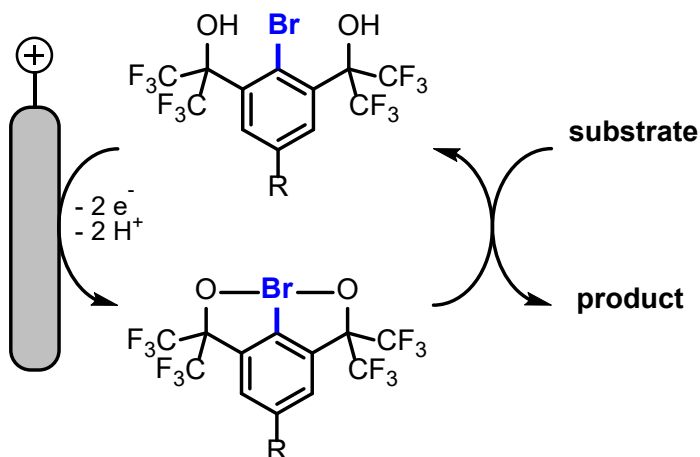
Igors Sokolovs<sup>1,2</sup>, Nayereh Mohebbati<sup>2,3</sup>

<sup>1</sup> Latvian Institute of Organic Synthesis Aizkraukles iela 21, Riga, Latvia, LV-1006

<sup>2</sup> Institute of Chemistry, Rostock University, Albert-Einstein-Str. 3a, 18059 Rostock, Germany

<sup>3</sup> Leibniz Institute for Catalysis, Albert-Einstein-Str. 29a, 18059 Rostock, Germany  
E-mail: igorss@osi.lv

The chemistry of hypervalent halogen species has experienced enormous progress in the last decades, and hypervalent iodine (III) compounds have become common reagents in modern organic synthesis. In sharp contrast, the chemistry of isoelectronic bromine (III) compounds occur to be notably less advanced to date. This dramatic difference obviously is to be connected with the relatively low stability and the high oxidizing power of bromine (III) reagents, which results in a difficult-to-control reactivity. Furthermore, there is a clear deficit of simple protocol for the synthesis of bromine (III) species, but known methods often require a handling of the highly toxic and corrosive  $\text{BrF}_3$  precursor. In this context, we present a straightforward and scalable method for preparation of a benchtop-stable  $\lambda^3$ -bromanes by anodic oxidation of corresponding aryl bromides with two stabilizing hexafluoro-2-hydroxypropanyl groups. The synthetic use of the generated  $\lambda^3$ -bromane is demonstrated by oxidative C-C, C-N, and C-O bond formation reactions [1].



### References

[1] Sokolovs, I.; Mohebbati, N.; Francke, R.; Suna, E. *Angew. Chem. Int. Ed.*, **2021**, *60*, 15832–15837.

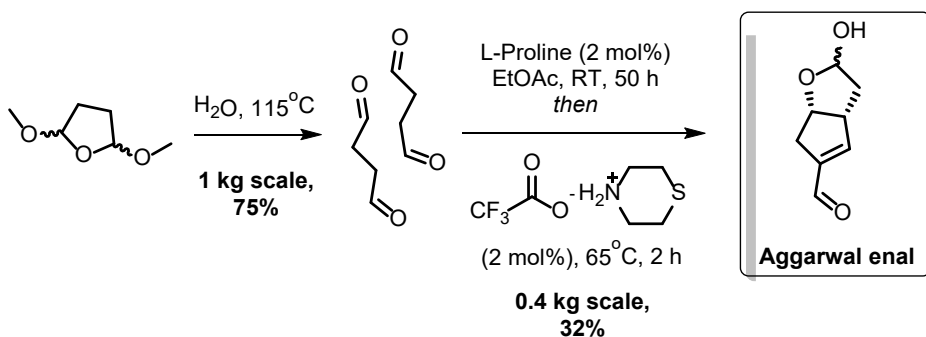
# SCALE-UP DEVELOPMENT OF AGGARWAL ENAL BICYCLIC INTERMEDIATE – TOWARDS MODERN MANUFACTURING OF PROSTAGLANDIN DRUGS

Andrejs Pelšs

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia, LV-1006  
E-mail: a-pelss@osi.lv

Prostanoids are important class of potent lipid mediators that are involved in the regulation of many biological processes such as inflammation, pain response and fever. This class of compounds has found wide-spread use as pharmaceuticals for the treatment of several diseases including pulmonary arterial hypertension and glaucoma (4.5 billion EUR global market). Recently a multitude of modern and short syntheses of various prostanoids were reported, rejuvenating this historically rich synthesis field. Remarkably short seven step synthesis of PGF<sub>2</sub>α reported by Aggarwal group in 2012 has good potential for industrialization [1].

Herein, we report the results of scale-up investigation of enantioselective two step route to Aggarwal enal bicyclic intermediate using extensively reoptimized reaction conditions [2]. Kilogram scale synthesis of succinaldehyde starting material was developed. Safety assessment of this volatile, unstable and polymerization prone compound was performed revealing recommended handling guidelines. Challenging organocatalytic dimerization of succinaldehyde was achieved on hectogram scale. The transfer from magnetically stirred small scale reactions to mechanically stirred large scale reactions in reactor required the finding of appropriate proline catalyst crystalline form [3].



## References

- [1] Coulthard, G.; Erb, W.; Aggarwal, V. K. *Nature*, **2012**, *489*, 278–281.
- [2] Pelšs, A.; Gandhamsetty, N.; Smith, J. R.; Mailhol, D.; Silvi, M.; Watson, A.; Perez-Powell, I.; Prévost, S.; Schützenmeister, N.; Moore, P.; Aggarwal, V. K. *Chem. Eur. J.*, **2018**, *24*, 9542–9545.
- [3] Pelšs, A.; Shubin, K. *Org. Process Res. Dev.*, **2022**, *accepted*, in revision.

# REPORTS

## SYNTHESIS OF 2-AMINOQUINAZOLIN-4(3H)-ONE BASED PLASMEPSIN INHIBITORS

**Emils Edgars Basens**

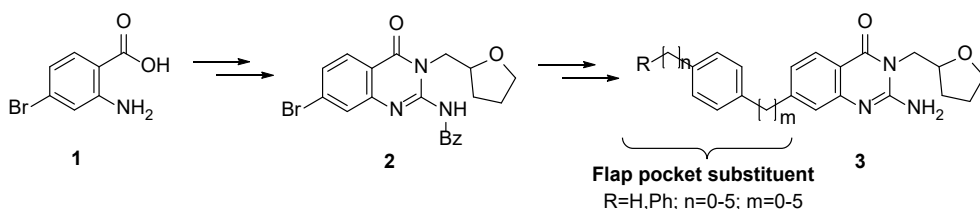
*Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia, LV-1006*

*E-mail: emils.edgars.basens@osi.lv*

Malaria is a deadly parasitic infection caused by Plasmodium parasites. The widespread resistance against available antimalarial drugs motivates scientists to develop new therapeutic agents targeting the life cycle of the parasite by novel mechanisms of action.

Plasmepsins (plm) are malarial aspartic proteases which have been proposed as appropriate antimalarial drug targets. It is important to design potent plm inhibitors, which do not inhibit other aspartic proteases like human cathepsin D. This can be achieved with nonpeptidomimetic inhibitors (e.g. 2-aminoquinazolin-4(3H)-ones<sup>1</sup>) that bind to the open-flap conformation of the pathogen enzyme.<sup>2</sup> Detailed structural and dynamic studies of mobile aspartic protease flap loop are required to develop more active and effective plm inhibitors. The effect of inhibitor on binding mode and conformation of the flap pocket can be studied using inhibitors with different flap pocket substituents and testing their activity against plasmepsins.

Here we present the synthesis of 2-aminoquinazolin-4(3H)-ones with different flap pocket substituents and their activities against plasmepsins.



Target molecules **3** were synthesized from building block **2** using Sonogashira reaction with alkynes or Suzuki-Miyaura reaction with vinyl, alkyl or aryl dioxaborolanes with subsequent saturation of unsaturated bonds in substituent and benzoyl group cleavage.

**Supervisors:** Dr. chem. D. Rasina, Dr. chem. R. Bobrovs.

### References

- [1] Rasina, D.; Otikovs, M.; Leitans, J.; Recacha, R.; Borysov, O. V.; Kanepe-Lapsa, I.; Domranceva, I.; Pantelejevs, T.; Tars, K.; Blackman, M. J.; Jaudzems, K.; Jirgensons, A. *J. Med. Chem.*, **2016**, 59, 374.
- [2] Bobrovs, R.; Jaudzems, K.; Jirgensons, A. *J. Med. Chem.*, **2019**, 62, 20, 8931.

# SYNTHESIS OF BETA-ADRENERGIC RECEPTOR AGONISTS FOR THE TREATMENT OF OBESITY

**Māris Bazulis**

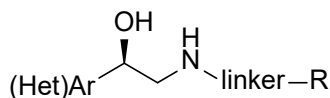
Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Rīga, Latvia

University of Latvia. Faculty of Chemistry, Jelgavas iela 1, Rīga, Latvia

E-mail: maris.bazulis@osi.lv

Several  $\beta$ -amino alcohols are known to act as dual  $\beta_2$ -/ $\beta_3$ - receptor agonists which promote glucose uptake in skeletal muscle cells [1]. Despite them being  $\beta_2$  agonists they cause negligible formation of cAMP in the heart and lungs, which is associated with the side effects of traditional  $\beta_2$  agonists. As  $\beta_3$ -receptor agonists they also promote thermogenesis and lipolysis in brown adipose tissue which increases resting energy expenditure. The combination of these effects can be used in order to develop new drugs for the treatment of obesity [1–2].

The aim of this project is to design and synthesize new  $\beta$ -amino alcohols as potential dual  $\beta_2$ -/ $\beta_3$ - receptor agonists (Fig. 1). The structure of the aryl- or heteroaryl- ring is tuned in order to reduce cAMP signaling through  $\beta_2$  receptors. The secondary amine is linked to different substituents R which increase selectivity towards the  $\beta_3$ - receptor.



**Fig. 1.** General structure of a dual  $\beta_2$ -/ $\beta_3$ - receptor agonist

**Supervisor:** Dr. chem. Ilga Mutule.

**Acknowledgements.** This work was supported by the Eurostars project – SYNSTAR: Synergistic Stimulation of Adrenergic Receptors for the Treatment of Obesity (2020–2023).

## References

- [1] Mukaida, S.; Sato, M.; Öberg, A. I.; Dehvari, N.; Olsen, J. M. et al. *Am. J. Physiol. Regul. Integr. Comp. Physiol.*, **2019**, 316, R666–R677.
- [2] Schena, G.; Caplan, M. J. *Cells*, **2019**, 8, 357.

# COBALT-CATALYZED AMINO ACID C(sp<sup>2</sup>)-H BOND FUNCTIONALIZATION USING ORGANIC ISOCYANIDES

Aleksandrs Čizikovs

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia, LV-1006

E-mail: aleksandrs.cizikovs@osi.lv

Over the last decade, high-valent cobalt catalysis has earned a place in the spotlight as a valuable tool for C-H activation and functionalization.<sup>1</sup> The use of cobalt (II) salt catalysts in combination with bidentate directing groups has been proven to be an effective strategy for various C-H bond transformations.<sup>2</sup> Not only cobalt is less expensive alternative to third row noble metals, but also displays similar reactivity and regioselectivity.<sup>3</sup>

Very recently, our group has developed a methodology for cobalt-catalyzed carbonylation of phenyl alanine derivatives **1** employing picolinamide (PA) as a traceless directing group (Scheme 1).<sup>2</sup> We have further developed this methodology by introducing isocyanides as C-H functionalization reagents. Herein we report a novel and efficient picolinamide directed method for the synthesis of 1,2-dihydroisoquinolines **4** via Co-catalyzed C-H functionalization of amino acid derivatives using organic isocyanides.

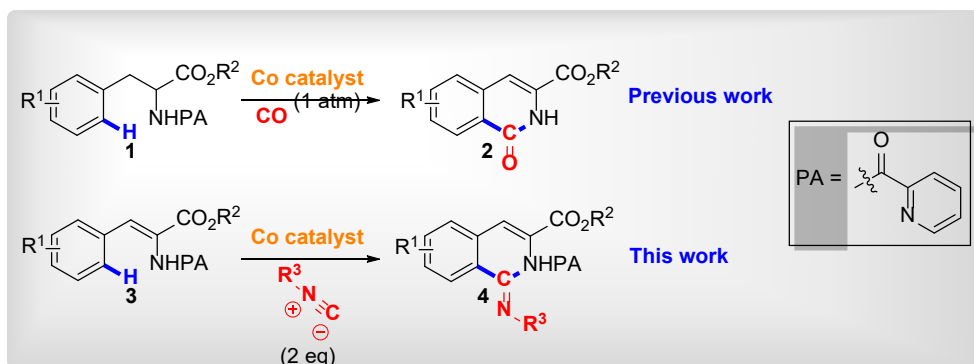


Fig. 1. Previous result and current work on phenyl alanine derivatives **1** and **3** transformations

**Supervisors:** Dr. Chem. Liene Grigorjeva, M. Sc. Ing. Lūkass Lukaševics.

## References

- [1] Lukasevics, L.; Cizikovs, A.; Grigorjeva, L. *Chem. Commun.*, **2021**, 57, 10827–10841.
- [2] Lukasevics, L.; Cizikovs, A.; Grigorjeva, L. *Org. Lett.*, **2021**, 23(7), 2748–2753.
- [3] Gandeepan, P.; Muller, T.; Zell, D.; Cera, G.; Warratz, S.; Ackermann, L. *Chem. Rev.*, **2019**, 119(4), 2192.



# A MECHANISTICAL STUDY OF LEWIS BASE CATALYZED CYANOHYDRIN SYNTHESIS

Artūrs Raimonds Feldmanis, Oto Filipsons

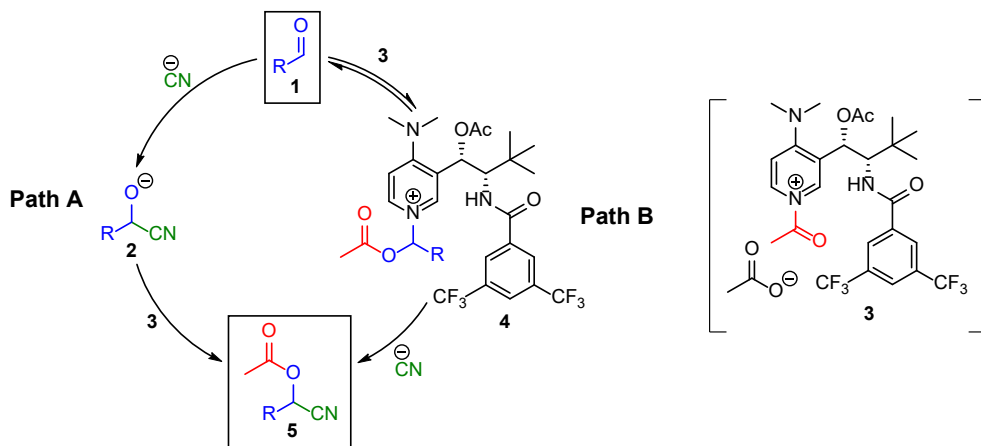
University of Latvia, Department of Chemistry, Jelgavas 1, Riga, Latvia, LV-1004

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia, LV-1006

E-mail: arturs.raimonds.feldmanis@osi.lv

Enantiopure cyanohydrins are valuable building blocks in organic and medicinal chemistry [1]. Both functional groups of cyanohydrins (nitrile and hydroxy group) can be easily modified giving access to a variety of valuable organic compounds such as  $\alpha$ -amino acids,  $\alpha$ -hydroxy acids and aziridines.

Herein we present chiral Lewis base-catalyzed synthesis of enantioenriched cyanohydrins (enantioselectivity up to 65:35 er) from aliphatic and aromatic aldehydes. In order to understand and improve the stereoselectivity, the mechanism of the reaction was investigated. Two potential reaction paths were identified and explored – first through the formation of a cyanohydrin anion **2** (path A) and second through the formation of a hemiaminal intermediate **4** (path B).



**Supervisor:** Dr. chem. A. Kinens.

**Acknowledgements.** Financial support from ERDF project No. 1.1.1.2/VIAA/3/19/589 is acknowledged.

## References

[1] North, M.; Usanov, D. L.; Young, C. *Chem. Rev.*, **2008**, *108*, 5146.

# SYNTHETIC APPROACH TOWARDS ENANTIOPURE CYCLIC SULFINAMIDES

Glebs Jersovs

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia

E-mail: glebs.jersovs@osi.lv

*N*-Alkylation of readily accessible Ellman's sulfinamide derivatives has become a routine step in preparation of enantiopure amines.<sup>1</sup> On the other hand, rarely exploited nucleophilic character of the *S*-atom in *tert*-butyl sulfinamides can be revealed in a serendipitously discovered intramolecular alkylation. High regio- and stereoselectivity of this transformation allows for facile preparation of diverse cyclic sulfinamides **3**. The latter are convenient enantiopure building blocks for medicinal chemistry owing to ample opportunities for diversification at the asymmetric *S*-atom and at the olefin site.

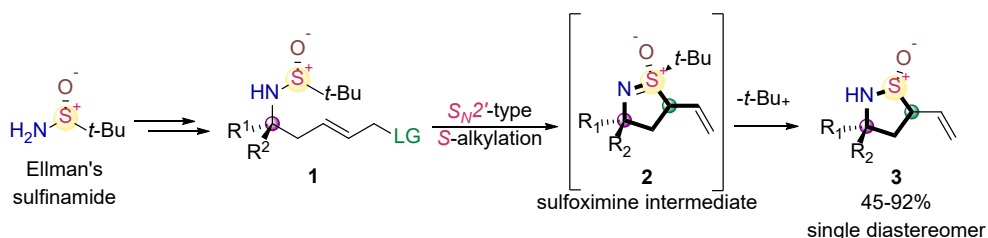


Fig. 1. Intramolecular *S*-cyclization of *tert*-butyl sulfinamides **1**

**Supervisors:** prof., Dr. chem. E. Suna, Dr. chem. P. Donets.

**Acknowledgements.** This project was funded by Latvian Institute of Organic Synthesis internal student grant IG-2021-04.

## References

[1] Robak, M. T.; Herbage, M. A.; Ellman, J. A. *Chem. Rev.*, **2010**, *110*, 3600.

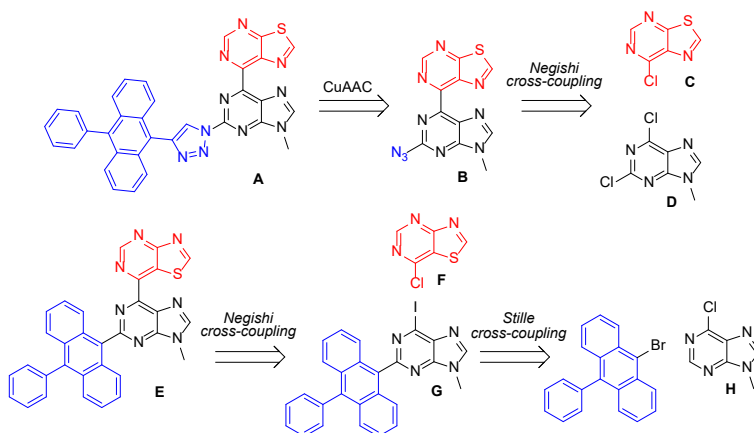
# SYNTHESIS OF PURINE-THIAZOLOPYRIMIDINE CONJUGATES

Kārlis Ēriks Kriķis, Zigfrīds Kapilinskis

*Institute of Technology of Organic Chemistry, Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena iela 3., Riga, Latvia, LV-1048*  
E-mail: karlis-eriks.krikis@rtu.lv; zigfrids.kapilinskis@rtu.lv

Purine derivatives have been studied not only as biologically active compounds but also as scaffolds for OLED materials. Recently, purine based derivatives have shown promising results as TADF (thermally activated delayed fluorescence) materials [1].

In this study we have designed new purine-thiazolopyrimidine conjugates **A** and **E** containing phenylanthracene moiety, later to be studied as TADF materials [2, 3]. Firstly, Negishi cross-coupling between thiazolopyrimidine **C** and purine **D** and subsequent  $S_NAr$  reaction with  $NaN_3$  will provide compound **B**. Then CuAAC reaction between **B** and phenylanthracenyl moiety containing alkyne will provide target derivative **A**. On the other hand, Stille cross-coupling between purine **H** and 9-bromo-10-phenylanthracene, and following Negishi cross-coupling with thiazolopyrimidine **F** will be used for the synthesis of conjugate **E**. The progress towards conjugates **A** and **E** will be discussed.



**Scheme 1.** Retrosynthetic analysis of target compounds **A** and **E**

**Supervisor:** Dr. chem. I. Novosjolova.

**Acknowledgements.** The authors thank MEPS co-project (LV-LT-TW) for financial support.

## References

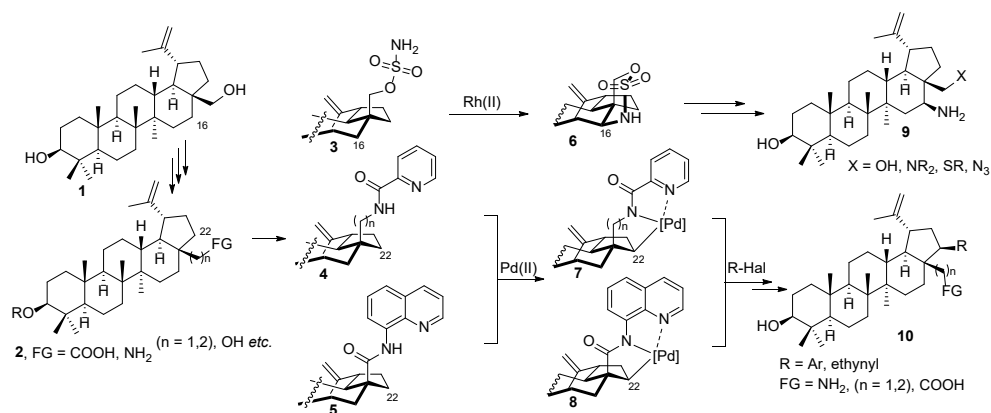
- [1] Wang, Z.; Yao, J.; Zhan, L.; Gong, S.; Ma, D.; Yang, C. *Dyes and Pigments.*, **2020**, *180*, 108437.
- [2] Gong, M.-S.; Lee, H.-S.; Jeon, Y.-M. *Beilstein J. Mater. Chem.*, **2010**, *20*, 10735.
- [3] Yokota, K.; Hagimori, M.; Mizuyama, N.; Nishimura, Y.; Fujito, H.; Shigemitsu, Y.; Tominaga, Y. *Beilstein J. Org. Chem.*, **2021**, *8*, 266–274.

# C-H ACTIVATION OF LUPANE TYPE TRITERPENOIDS

Vladislavs Kroškins, Jevgeņija Lugiņina, Kristiāns Jankovičs

Institute of Technology of Organic Chemistry, Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena iela 3, Riga 1048, Latvia  
E-mail: vladislavs.kroskins@rtu.lv

Betulin **1** is pentacyclic triterpenoid natural product that is obtained as secondary metabolite in more than 200 different types of plants. Betulin and its derivatives exhibit several important pharmacological properties such as antitumor, anti-inflammatory, antiparasitic, and anti-viral activities [1]. The aim of this work is to observe novel biologically active betulin derivatives by CH functionalization at C(16) and C(22). For this purpose, precursors bearing different directing groups were synthesized.



8-Sulfamate ester **3** was used for *Du Bois*  $\gamma$ -C-H bond amination *via* formation of oxathiazinane **6** [2]. Intermediate **6** can be further converted into differently functionalized compounds **9** through the ring opening reactions.

8-Aminoquinoline amide **5** and picoline amides **4** were combined successfully with aryl halogenides and haloalkynes in the *Daugulis* CH activation conditions [3].

**Supervisors:** Dr. chem. J. Lugiņina, Dr. chem. M. Turks.

## References

- [1] Xiao, S.; Tian, Z.; Wang, Y.; Si, L.; Zhou, D. *Med. Res. Rev.*, **2018**, 38, 951.
- [2] Espino, C. G.; Wehn, P. M.; Chow, J.; Du Bois, J. *J. Am. Chem. Soc.*, **2001**, 123, 6935–6936.
- [3] Zaitsev, V. G.; Shabashov, D.; Daugulis, O. *J. Am. Chem. Soc.*, **2005**, 127, 13154–13155.

# AZIDE-TETRAZOLE EQUILIBRIUM IN PYRIDO[2,3-*d*]PYRIMIDINES

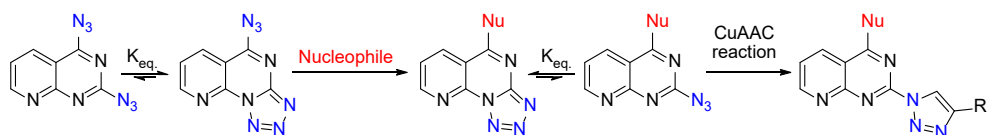
Kristaps Leškovskis

*Institute of Technology of Organic Chemistry, Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena iela 3, Riga, Latvia, LV-1048  
E-mail: kristaps.leskovskis@rtu.lv*

Azido groups in nitrogen heterocycles, if adjacent to annular nitrogen, can spontaneously cyclize to fused tetrazole or at least persist in azide-tetrazole equilibrium [1]. Azide-tetrazole valance tautomerism is considered as a reversible intramolecular 1,5-dipolar cycloaddition with azide tautomer being thermodynamically more stable. However, azide formation is endothermic process, thus azide tautomer is favored at higher temperatures and tetrazole in lower temperatures. The main tautomeric form and equilibrium constant essentially depends on substituents, temperature and solvent polarity. Thus, one can steer azide-tetrazole equilibrium with careful choice of reaction conditions.

While tetrazole tautomer as a fused cycle is unreactive, the open chain azido tautomer can be functionalized as a classical azide. This concept can be used for masking azido functional group [2] and regioselectivity induction in compounds with more than one tautomeric azide [3].

The present study discusses regioselectivity of azido group functionalization in 2,4-diazidopyrido[2,3-*d*]pyrimidine, reactivity of substituted tetrazolo[1,5-*a*]pyrido[3,2-*e*]pyrimidine and equilibrium constants thereof.



**Scheme 1.** Azide-tetrazole tautomerism in pyrido[2,3-*d*]pyrimidines

**Supervisors:** Dr. chem. M. Turks, Dr. chem. I. Novosjolova.

## References

- [1] a) Sebris, A.; Turks, M. *Chem. Het. Comp.*, **2019**, 55, 1041–1043 6; b) Deev, S. L.; Shestakova, T. S.; Charshin, V. N.; Chupakhin, O. N. *Chem. Het. Comp.*, **2017**, 53, 963–975.
- [2] Savateev, K. V.; Fedotov, V. V.; Ulomskiy, E. N.; Rusinov, V. L. *Chem. Het. Comp.*, **2018**, 54, 197–204.
- [3] Jeminejs, A.; Goliškina, S. M.; Novosjolova, I.; Stepanovs, D.; Bizdēna, Ē.; Turks, M. *Synthesis*, **2020**, 53, 1443–1456.

# SYNTHESIS OF BICYCLIC PROLINE ANALOGUES

**Mērija Meiberga**

University of Latvia, Jelgavas iela 1, Rīga, Latvia, LV-1004

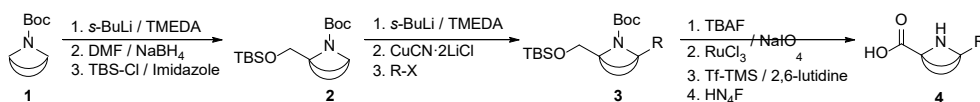
Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Rīga, Latvia, LV-1006

E-mail: merija.agnese.meiberga@osi.lv

$\alpha$ -Amino acids are widely used in drug design and peptide chain synthesis. Proline is the only cyclic natural amino acid, therefore its conformational rigidity plays an important role in protein secondary structures, such as alpha helices.

Herein we report the synthesis of previously unreported bicyclic amino acid derivatives **4** substituted at bridgehead positions. These amino acids are even more conformationally rigid than proline, thereby ensuring that substituents are at fixed positions relative to one another.

The key intermediate that is used for synthesis of amino acid **4** is TBS protected amino alcohol **2**, which is obtained by  $\alpha$  - lithiation of *N*-Boc protected bicycle **1**. The next lithiation step allows convenient functionalization of the other bridgehead position. Diversity of derivatives **3** can be achieved using transmetalation of organolithium intermediate with CuCN·2LiCl complex, which allows the use of a broad scope of electrophiles R-X.



Amino acid precursors **3** are deprotected and oxidized to give bicyclic  $\alpha$  - amino acids **4**.

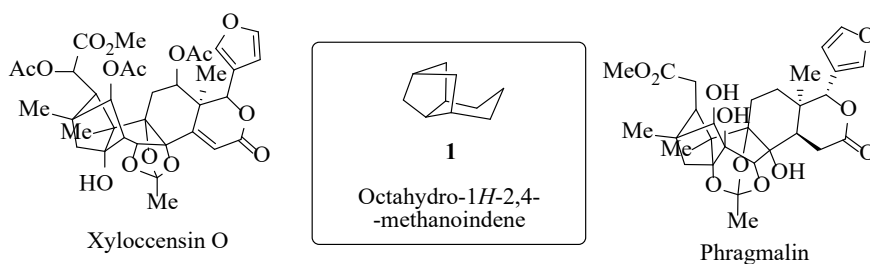
**Supervisor:** Dr. chem. I. Mutule2.

# DEVELOPMENT OF SYNTHESIS PATHWAYS FOR THE LIMONOID OCTAHYDRO-1*H*-2,4-METHANOINDENE SCAFFOLD

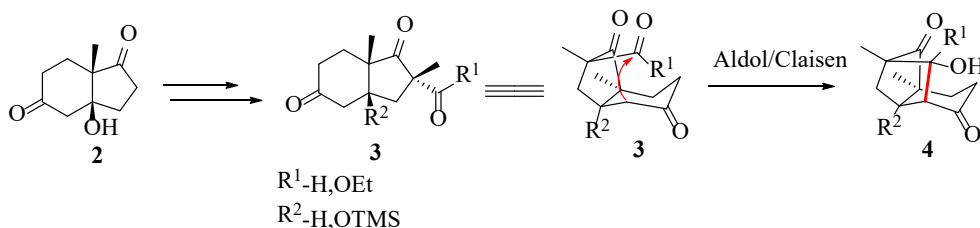
**Olavs Rāciņš**

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Rīga, Latvia  
E-mail: olavs.racins@osi.lv

The octahydro-1*H*-2,4-methanoindene (**1**) scaffold is present in various limonoid natural products, such as phragmalin, xylocensins and others [1]. Limonoid natural products exhibit a wide range of pharmacological properties, including anti-HIV, antibiotic, anti-cancer, anti-malarial, and anti-viral activities [2], therefore, are of high synthetic interest. Some methods for the construction of the scaffold **1** are known [3, 4]. However, the total syntheses of phragmalin-type limonoids have not been performed yet. As a part of total synthesis project of Libiguin A, we explore a pathway for a stereodefined assembly of scaffold **1** with a substitution pattern beneficial for further functionalisation.



The synthesis pathway involves the modification of the Hajos-Parrish ketol (**2**) to obtain compounds **3**. Furthermore, compounds **3** were subjected to Aldol/Claisen type condensations to yield the octahydro-1*H*-2,4-methanoindene scaffold **4**.



**Supervisors:** Dr. chem. Joseph Becica, Dr. chem. Prof. Aigars Jirgensons.

## References

- [1] Roy, A.; Saraf, S. *Biol. Pharm. Bull.*, **2006**, *29*, 191–201.
- [2] Heasley, B. *Eur. J. Org. Chem.*, **2011**, *2011*, 19–46.
- [3] Li, Y.; Li, J. X.; Ouyang, X. H.; Wang, Q. A.; Li, J. H. *Org. Lett.*, **2017**, *19*, 6172–6175.
- [4] Lebold, T. P.; Gallego, G. M.; Marth, C. J.; Sarpong R. *Org. Lett.*, **2012**, *14*, 2110–2113.

# THIAZOLINE CARBENE-Cu(I)-CARBAZOLIDE COMPLEXES AS LUMINESCENT TADF MATERIALS

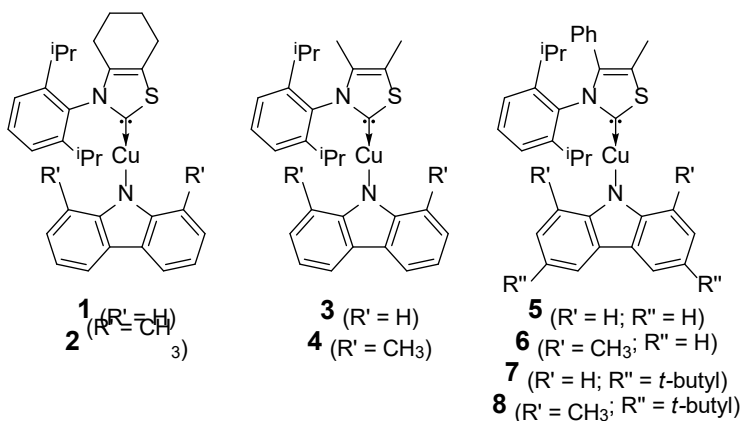
Armands Rudušs, Žanis Sisojevs, Annija Jēce

Riga Technical University, 3/7 Paula Valdena iela, Riga, Latvia, LV-1048

E-mail: armands.ruduss@rtu.lv

Highly luminescent two coordinate linear carbene-metal-amide (CMA, metal = Cu, Ag, Au) complexes with short radiative lifetimes have emerged as a highly promising direction towards TADF materials [1, 2]. However, structural diversity of CMAs with potential OLED application is still limited to a handful of *N*-heterocyclic carbene (NHC) structures. In this report we demonstrate luminescent CMAs based on 1,3-thiazoline NHC fragment.

A series of complexes **1–8** composed of thiazoline carbene-Cu(I)-carbazolides was synthesized. In PMMA matrix complexes exhibit sky-blue to bluish green emission ( $\lambda_{\text{max}} = 471\text{--}509\text{ nm}$ ) with TADF emissive properties and  $\Phi_{\text{pl}}$  reaching 0.86 for compound **8**. Radiative rates in the range of  $2.8\text{--}7.2 \times 10^5\text{ s}^{-1}$  were attained. An increase of the emissive rates was observed with the introduction of sterically demanding substituents at both the carbazole (1,8-dimethyl- groups, compounds **2**, **4**, **6** and **8**) and thiazoline (4-phenyl- group, compounds **5–8**). The interactions of the bulky groups induces sterical locking, which increases coplanarity of carbazolidide and thiazoline ligands. Emitter **7** was successfully integrated in vacuum-deposited OLEDs with external quantum efficiency reaching 16.5%.



**Supervisor:** Dr. chem. K. Traskovskis.

**Acknowledgements.** This research is funded by Latvian Council of Science, project No. LZP-2019/1-0231.

## References

- [1] Di, D. et al. *Science*, **2017**, 356, 159–163.
- [2] Hamze, R. et al. *Science*, **2019**, 363, 601–606.



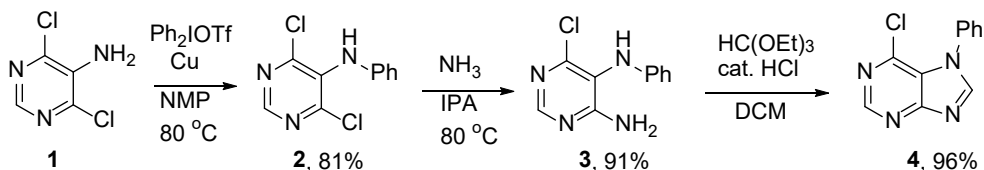
# NEW SYNTHETIC APPROACH FOR THE SYNTHESIS OF SUBSTITUTED 7-ARYLPURINES

Armands Sebris

*Institute of Technology of Organic Chemistry, Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena iela 3, Riga, Latvia  
E-mail: armands.sebris\_1@rtu.lv*

Alkylation and arylation on the purine ring usually proceeds almost selectively at N(9) position. While there are some simple pathways to introduce alkyl substituents at N(7) [1], the same is not true for introduction of aryl groups. The most commonly used Cu catalyzed Chan-Lam reaction [2] and arylation with iodanes [3] selectively give N(9) product. The few existing methods for purine N(7) arylation still provide a mixture of two isomers and are substrate dependent [4]. Hence, we decided to test various pathways towards 7-arylpurines starting from substituted pyrimidines.

We have achieved the best results with the following synthetic pathway starting from compound **1**: arylation was performed using diaryliodonane in the presence of Cu catalyst, giving 5-arylamino substituted pyrimidine **2**. Next, in  $S_NAr$  reaction under optimized conditions only one chlorine atom was substituted. Finally 7-arylpurine was obtained in a ring closing reaction with orthoester under acidic conditions. Modifications of starting material **1**, diaryliodonane reagent and ring closing reagent can be made to achieve differently substituted 7-arylpurines of type **4**.



**Supervisors:** Dr. chem. M. Turks, Dr. chem. I. Novosjolova.

**Acknowledgment.** This work was supported by the Latvian Council of Science grant No LZP-2020/1-0348.

## References

- [1] Kotek, V.; Chudikova, N.; Tobrman, T.; Dvorak, D. J. *Org. Lett.*, **2010**, *12*, 5724.
- [2] Traskovskis, K.; Sebris, A.; Novosjolova, I.; Turks, M.; Guzauskas, M.; Volyniuk, D.; Bezikonnyi, O.; Grazulevicius, J. V.; Mishnev, A.; Grzibovskis, R.; Vembris, A. *J. Mater. Chem. C*, **2021**, *9*, 4532.
- [3] Niu H.-Y.; Xia, C.; Qu, G.-R.; Zhang, Q.; Jiang, Y.; Mao, R.-Z.; Li, D.-Y.; Guo, H.-M. *Org. Biomol. Chem.*, **2011**, *9*, 5039.
- [4] Keder, R.; Dvorakova, H.; Dvorak, D. *Eur. J. Org. Chem.* **2009**, *10*, 1522.

# COPPER(I) CATALYZED AZIDE-ALKYNE CYCLOADDITION IN IONIC LIQUIDS

**Diāna Sloboda**

*Faculty of Chemistry, University of Latvia, Jelgavas iela 1, Riga, Latvia, LV-1004*

*E-mail: diana.sloboda@lu.lv*

Since 2002 when Meldal [1] and Sharpless [2] independently discovered a copper effect on azide-alkyne cycloaddition (Huisgen reaction), the copper(I) catalyzed azide-alkyne cycloaddition (CuAAC) reaction has gained a popularity and attention from scientists in various fields. CuAAC can be carried out in a variety of molecular solvents ranging from the nonpolar toluene and dichloromethane, to the polar acetonitrile and *N,N*-dimethylformamide, and even in aqueous solutions.

We have extended the scope of the CuAAC reaction by using ionic liquids (ILs) as reaction media. In this work the impact of IL structure and composition on benzylazide-phenylacetylene CuAAC reaction kinetics was investigated. Kinetic data were acquired by <sup>1</sup>H NMR spectroscopy. The effects of coordinating and non-coordinating IL anions regarding CuAAC reaction kinetics were tested. The importance of water content in this system is demonstrated by remarkable changes in reaction kinetic curves.



**Supervisor:** Dr. chem. E. Baķis.

## References

- [1] Tornøe, C. W.; Christensen, C.; Meldal, M. *J. Org. Chem.*, 2002, 67, 9, 3057–3064
- [2] Rostovtsev, V. V.; Green, L. G.; Fokin, V. V.; Sharpless, K. B. *Angew Chem Int Ed Engl.*, 2002, 41, 14, 2596–9.

# SYNTHESIS OF 2-AMINOQUINAZOLINES AND INDAZOLES FROM 2-FORMYLPHENYLBORONIC ACIDS

Vitalii Solomin

Latvian Institute of Organic Synthesis, Aizkraukles iela 21, Riga, Latvia, LV-1006

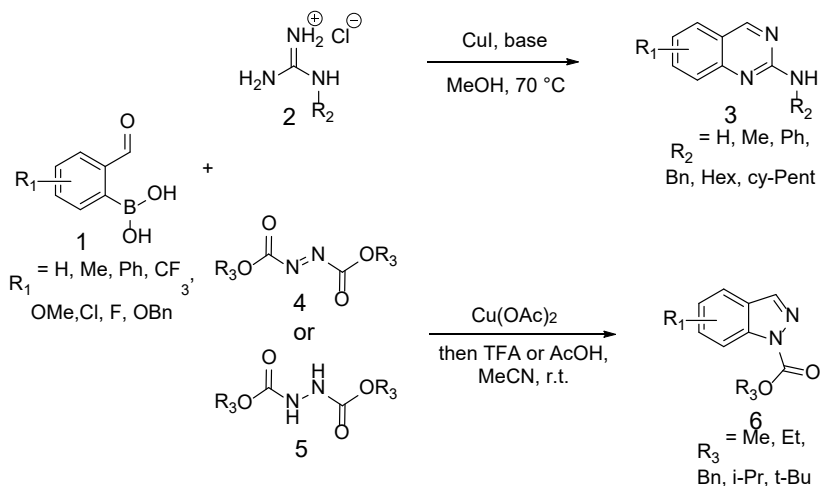
Faculty of Materials Science and Applied Chemistry, Paula Valdena iela 3, Riga, Latvia, LV-1048

E-mail: vitalijs.solomins@osi.lv

New methods for the synthesis of the fused heterocyclic cores such as indazole and 2-aminoquinazoline has been studied and developed. Using discovered technique, 2-formylphenylboronic acids (1) can be converted to the target heterocycles in a mild conditions.

For 2-aminoquinazoline synthesis (3), variously substituted guanidines (2) has been used. Reaction proceeds in alcoholic media with Cu (I) iodide as a catalyst (Chan-Evans-Lam reaction conditions adaptation) [1].

N-protected indazoles can also be accessed by replacement of the starting materials. Both dialkyl azodicarboxylates (4) and dialkyl hydrazinedicarboxylates (5) can be used for the construction of indazole core (6). Protocol involves coupling stage, mediated by Cu (II) acetate, with subsequent one-pot conversion of formed semi-product to indazole in acidic media [2].



Reported procedures are simple in operation and leading to the target 2-aminoquinazolines (3) or alkyl 1 *H*-indazole-1-carboxylates (6) with a moderate yields.

**Supervisor:** Prof. A. Jirgensons.

## References

[1] Solomin, V. V.; Seins A.; Jirgensons A. *Synlett*, **2020**, 31, 1507–10.

[2] Solomin, V. V.; Seins A.; Jirgensons A. *RSC Advances*, **2021**, 11, 22710–14.