COURSE DESCRIPTION CARD - SYLLABUS

Course name
NATURE-INSPIRED SOLVENTS AND SORBENTS AS GREEN APPROACH FOR SAMPLE PREPARATION IN ANALYTICAL CHEMISTRY [S5NC>RSIN]

Course

Proposed by Discipline
–

Year/Semester
2/4

Level of study
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

Doctoral student as theoretical and practical knowledge at academic level in the field of analytical chemistry and instrumentation methods, in particular: knows the chromatographic and spectroscopic techniques, basic sample preparation techniques, principles of Green Analytical Chemistry. Doctoral student as theoretical and practical knowledge at academic level in the field of organic chemistry, in particular: synthesis and properties of sorbents e.g. biopolymers.

Course objective

Main goal of lecture is presentation of pro-ecological trends in sample preparation techniques (liquid-phase microextraction techniques using nature-inspired extraction solvents and solid-phase microextraction techniques using nature-inspired sorbents).

Course-related learning outcomes

KNOWLEDGE
A doctoral student knows and understands:
- key developmental trends of disciplines of science in which education at the Doctoral School takes place (P8S_WG/SzD_W02)
- scientific research methodology in disciplines represented at the Doctoral School (P8S_WG/SzD_W03)

SKILLS
A doctoral student can:
- use knowledge from different branches of science to creatively identify, formulate and innovatively solve complex problems or to perform research tasks such as: define the aim and subject of scientific research, form a research hypothesis, develop research methods, techniques and tools and use them creatively, draw conclusions on the basis of research results (P8S_UW/SzD_U01)
- communicate on specialist issues on the level that allows active participation in the international scientific community (P8S_UK/SzD_U04)
- plan and implement individual and team research projects, also in the international community (P8S_UO/SzD_U09)

SOCIAL COMPETENCIES
A doctoral student is ready to:
- acknowledge the importance of knowledge in solving cognitive and practical problems (P8S_KK/SzD_K03)
- maintain and develop the ethos of research and creative communities, including: conducting independent scientific activity, respecting the principle of public ownership of the results of scientific activities, including the principles of intellectual property protection.(P8S_KR/SzD_K07)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The learning outcomes will be assessed in two parts:

10 points for a report determining the pro-ecological nature of a selected analytical procedure using selected greenness tools/metrics (NEMI, Analytical Eco-Scale, ComplexMoGAPI, AGREEPrep, BAGI, Hexagon), discussing the obtained results, and providing conclusions.

10 points - as part of a test (10 test questions) covering topics discussed during the lecture.

A total of 20 points (100%) can be awarded.

Assignment of grades to percentage ranges:
above 50% - 60.0%: 3.0
above 60% - 70.0%: 3.5
above 70% - 80.0%: 4.0
above 80% - 90.0%: 4.5
above 90% - 100%: 5.0

Programme content

Familiarization with new, pro-ecological trends in sample preparation techniques. A review of liquid-phase microextraction techniques using nature-inspired extraction solvents. A review of solid-phase microextraction techniques using nature-inspired sorbents. Determining the greenness of selected analytical methods using Green Analytical Chemistry metrics.

Course topics

1. Introduction to sample preparation in analytical chemistry
2. Green Analytical Chemistry - principles and metrics of greenness
3. Liquid-phase microextraction techniques
- Fundamentals of LPME techniques: DLLME, SDME, HF-LLME, USAEME
- Types of nature-inspired solvents to extraction: bio-ionic liquids, (natural) deep eutectic solvents, switchable hydrophobility solvents, bio-based solvents (e.g. limonene, pinene, ethyl lactate), sub- and supercritical fluids, supramolecular solvents
- Examples of analytical procedures with GAC metrics calculation (NEMI, Analytical eco-scale, GAPI, ComplexMoGAPI, AGREEPrep, BAGI,
Hexagon)
4. Sorbent-based (micro)extraction techniques (SBME)
- Fundamentals of SBME techniques: SPME, TFME, SBSE, SPE, PT-SPE, BaμE, RDSE, μSPE, d- μSPE,

M-d-μSPE
- Types of sorbents: molecularly imprinted polymers (MIPs), metal-organic frameworks (MOFs), carbon-based nanomaterials, immunosorbents,
- When sorbents are green?
- Nature-inspired sorbents to SBME: biopolymers (chitosan, cellulose, alginate, argarose, starch, cyclodextrins), biowaste (coffee residues, bracts and peels of various fruits, cork), natural products (cork, cotton, pollen, kapok, bamboo, alrae, various seeds)
- Sorbents modified by (natural) deep eutectic solvents and `eutectosorbents` as future perspective
- Examples of analytical procedures with GAC metrics calculation (NEMI, Analytical eco-scale, GAPI, ComplexMoGAPI, AGREEPrep, BAGI,
Hexagon)
5. Summary and future trends in sample preparation

Teaching methods

Interactive lecture: multimedia presentation, illustrated with examples of analytical procedures based on nature-inspired solvents/sorbents and calculate of greenness of them using popular GAC metrics.

Bibliography

BASIC:
1. Chaudhery Mustansar Hussain, Javier Hernandez-Borges, Green Sample Preparation Techniques: Concepts, Novel Materials and Solvents, and Applications (Green Chemistry Series, Volume 75) 1st Edition, Royal Society of Chemistry 2023
2. Antonio V. Herrera-Herrera, Bárbara Socas-Rodríguez, Microextraction Techniques: Fundamentals, Applications and Recent Developments, Springer International Publishing, 2025.
3. Somenath Mirta, Sample Preparation Techniques in Analytical Chemistry. John Wiley & Sons 2003.(or next editions)
4. Meiyun Shi, Xinyue Zheng, Ning Zhang, Yufeng Guo, Meichen Liu, Lei Yin,
Overview of sixteen green analytical chemistry metrics for evaluation of the greenness of analytical methods, TrAC Trends in Analytical Chemistry, 166 (2023) 117211. https://doi.org/10.1016/j.trac.2023.117211.

ADDITIONAL:
1. Justyna Werner, Agnieszka Zgoła-Grześkowiak, Tomasz Grześkowiak, Robert Frankowski, Biopolymers-based sorbents as a future green direction for solid phase (micro)extraction technique. TrAC Trends in Analytical Chemistry 173 (2024) 117659 https://doi.org/10.1016/j.trac.2024.117659
2. Justyna Werner, Robert Frankowski, Tomasz Grześkowiak, Agnieszka Zgoła-Grześkowiak, Green sorbents in sample preparation techniques – naturally occurring materials and biowastes. TrAC Trends in Analytical Chemistry 176 (2024) 117772 https://doi.org/10.1016/j.trac.2024.117772
3. Vasil Andruch, Alina Kalyniukova, Justyna Płotka-Wasylka, Natalia Jatkowska, Denys Snigur, Serhii Zaruba, Julia Płatkiewicz, Agnieszka Zgoła-Grześkowiak, Justyna Werner, Application of deep eutectic solvents in sample preparation for analysis (update 2017–2022). Part A: Liquid phase microextraction. Microchemical Journal 189 (2023) 108509
https://doi.org/10.1016/j.microc.2023.108509
4. Justyna Werner, Agnieszka Zgoła-Grześkowiak, Julia Płatkiewicz, Justyna Płotka-Wasylka, Natalia Jatkowska, Alina Kalyniukova, Serhii Zaruba, Vasil Andruch, Deep eutectic solvents in analytical sample preconcentration Part B: Solid phase (micro)extraction, Microchemical Journal, 191 (2023) 108898. https://doi.org/10.1016/j.microc.2023.108898

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	8	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	42	2,00