

Chemistry - workshops

Workshops in research teams. Each candidate will declare their willingness to cooperate with a given research team at the recruitment stage, selecting the appropriate topic. These will be stationary classes carried out in modern research laboratories. Each student has to obligatorily complete one topic from presented below:

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1. Unlocking the Science of Kombucha: Active Compounds in Fermented Drinks

Joanna Orzeł, PhD

During the workshop, participants will explore how hot and cold extraction methods impact the quality of kombucha, using black, green, and white teas to see how raw materials influence fermentation. They will monitor SCOBY growth throughout the process, gaining practical insight into conditions that support optimal microbial development.

Each sample will be analyzed for polyphenols and antioxidant capacity using professional techniques such as the Folin–Ciocalteu and DPPH methods with UV-Vis spectrophotometry. Students will independently perform the full workflow—from parameter optimization to data interpretation—building valuable analytical skills. By combining hands-on fermentation with data-driven evaluation, the project reveals which extraction method provides the strongest health-related benefits, how polyphenols relate to antioxidant activity, and how bioactive compounds influence SCOBY growth, making it an appealing choice for anyone interested in functional beverages and modern analytical chemistry.

2. Understanding photoinduced photophysical processes of Ir(III) bichromophore through spectroscopic techniques

Joanna Palion-Gazda, PhD, Katarzyna Choroba, PhD

The workshop aims to provide knowledge required to explore photophysical processes in photoexcited transition metal complexes and to assess their potential in photocatalysis, photodynamic therapy (PDT), and triplet-triplet annihilation up-conversion (TTA-UC). The investigations will be performed for **bis-cyclometalated Ir(III) complex with** a π -conjugated organic chromophore. The photophysical behavior of such systems is governed by the relative energies of $^3\text{MLCT}$ (metal-to-ligand charge transfer) and ^3IL (intra-ligand). Three scenarios can

arise: (i) $^3\text{MLCT}$ state lies lower in energy than ^3IL ; (ii) the states are close in energy, enabling equilibrium, where ^3IL repopulates the luminescent $^3\text{MLCT}$; (iii): a long-lived, non-emissive ^3IL lies lower in energy than $^3\text{MLCT}$.

Within the workshop, student will conduct comprehensive photophysical studies of the selected Ir(III) complex to determine the nature of its ground and excited states, probe the dynamics of the lowest triplet formation, and preliminary assess the complex's efficacy as a photosensitizer.

3. Study of properties of ionic liquids with functionalized multiwalled carbon nanotubes (ionanofluids) as heat transfer fluids

Prof. Marzena Dzida

The current situation in the global economy requires the search for alternative energy sources and the optimization of current energy technologies, including, inter alia, searching for innovative working fluids, including heat transfer fluids. An alternative to the currently used HTFs may be systems of ionic liquids with nanoparticles (ionanofluids). Systems containing functionalized multiwalled carbon nanotubes and ionic liquids are characterized by potentially superior thermophysical properties such as thermal conductivity and isobaric heat capacity compared to pure ionic liquids and nanofluids, resulting in effective, low volatility, safe, advanced heat transfer fluids in both cooling and systems solar. The student will conduct a comprehensive study including the development of an optimal procedure for the preparation of ionanofluids, determination of the sedimentation stability of the obtained dispersions and determination of the density, isobaric heat capacity, thermal conductivity, and viscosity of selected ionanofluids. Based on the obtained results and their comparative analysis, the Student will determine the impact of the structure of functionalized multiwalled carbon nanotubes on the thermal properties of ionanofluids in the context of their potential applications as working fluids.

4. X-ray Fluorescence Analysis of Food Products

Prof. Rafał Sitko

Modern food production requires effective quality and safety control methods that enable the detection of both essential nutrients and potentially harmful contaminants. Analyzing the elemental composition of food products is a crucial tool for evaluating their nutritional value and ensuring compliance with relevant standards. Determining the content of heavy metals, such as arsenic, lead, and mercury, is crucial for consumer health. Identifying essential elements, including calcium, iron, zinc, copper, and magnesium, helps determine the extent to which a product supports healthy body function.

During the workshop, participants will learn one of the most important spectroscopic technique used in food analysis: X-ray fluorescence spectrometry (XRF). Students will become familiar with the operation of the instrument, learn how to interpret X-ray spectra, and optimize measurement conditions. They will also explore various calibration and quantitative methods, as well as sample preparation techniques using modern laboratory equipment. Throughout the workshop, students will prepare samples of selected food products (e.g., rice, coffee, vegetables, superfood, seafood, supplements), conduct measurements, interpret the obtained spectra, perform quantitative analyses, and compare the elemental composition of different products.

5. Multielemental analysis of tea and herbal infusions using Total Reflection X-ray Fluorescence Spectrometry (TXRF)

Karina Kocot, PhD

The exercise involves analyzing the content of selected elements in infusions prepared from various species of teas and herbs using Total Reflection X-ray Fluorescence Spectrometry (TXRF). The TXRF method enables simultaneous determination of multiple elements in liquid samples, with minimal sample preparation and high analytical sensitivity.

During the workshop, infusions prepared from different types of tea (black, green, red) and popular herbs used for culinary and medicinal purposes (e.g., mint, lemon balm, chamomile, nettle) are examined. Samples are prepared in several variants

differing in brewing time and temperature, which allows observation of changes in elemental content depending on extraction parameters.

6. In search of new solutions in optical technologies – analysis of the potential utility of selected materials as infrared emitters operating within telecommunication windows

Natalia Żak, PhD, Marta Kuwik, PhD

In the era of the digital revolution, when the information flow becomes faster and more efficient, it is urgent to search for materials capable of transmitting and processing the electromagnetic radiation. Thus, the optical fibers constitute as essential components of the telecommunication infrastructure. Due to the unique specifications of the materials used for fiber production (particularly related to their attenuation correlated with optical signal losses), it is highly necessary to design optical systems that emit radiation within specific spectral ranges, commonly known as telecommunication windows.

During the workshop, the student will participate in the design of materials that can be used as near-infrared emitters. The properties of the systems will be verified by recording emission spectra and analyzing the luminescence decay kinetics. The student will be able to analyze spectroscopic parameters and discuss the potential applications of the designed materials as infrared emitters operating within telecommunication windows.

7. Differential Scanning Calorimetry (DSC) and Thermogravimetry (TG) in practice - from theory to interpretation of results

Ewa Pietrasik, PhD, Eng. Assoc. Prof.

The workshop will cover differential scanning calorimetry (DSC) and thermogravimetry (TG). These research methods enable the determination of properties of tested materials, such as glass transition temperature, melting/crystallization temperature and heat of crystallization of newly synthesized compounds, thermal degradation of materials, and the observation of polymorphic changes in substances. Topics include a discussion of the theoretical aspects of differential calorimetry, with particular emphasis on DSC and TG measurement techniques. Additionally, students will be

introduced to processing measurement data using Excel and Origin, as well as the analysis of recorded curves obtained from the measurements.

8. Imaging innovation for pharmaceutical quality control

Łukasz Pieszczek, PhD

This hands-on workshop introduces participants to modern imaging techniques used in pharmaceutical quality control. Attendees will learn how to prepare reference drug samples for non-invasive spectroscopic analysis and explore the rapidly evolving field of hyperspectral imaging. The workshop will also compare hyperspectral methods with advanced confocal imaging techniques commonly used in university research labs.

Participants will gain practical experience in designing experiments using pharmaceutical samples and learn the fundamentals of image data processing in a contemporary laboratory setting. This session is ideal for those interested in bridging analytical chemistry with real-world pharmaceutical applications.

9. Caffeine under the magnifying glass: Exploring methylxanthines in everyday foods

Łukasz Pieszczek, PhD

In this laboratory workshop, participants will learn how to analyze popular food and beverage products for methylxanthines, such as caffeine and taurine, compounds widely monitored in the food industry. Through guided lab work, attendees will learn how to prepare complex food samples for analysis and apply quantitative techniques to estimate the concentrations of compounds.

The workshop offers hands-on training in High-Performance Thin-Layer Chromatography (HPTLC), utilizing state-of-the-art instruments, including TLC applicators, densitometers, and visualizers. Participants will discover how thin-layer chromatography is used in modern food quality control.

10. Energetic Behavior of Materials: The Role of Composition and Surface Characteristics

**Prof. Yuriy Bushuev, Dimitrios Skondras-Giousios, PhD,
Tomasz Wasiak, PhD, Eng.**

In this workshop, students will investigate materials with diverse surface and compositional characteristics to assess their energy-related properties and potential applications. The experimental component will focus on preparing materials and fabricating thin films to study the processes by which mechanical energy is harvested, stored, and converted into electrical energy. A range of instrumental techniques will be employed, including drop shape analysis, pressure–volume–temperature (PVT) measurements, atomic force microscopy (AFM), a cyclical force generator, laser flash analysis (LFA), and computer-based simulations. Participants will gain comprehensive hands-on experience, spanning material preparation through final device fabrication.

11. Design of innovative polymer materials for new drug delivery systems

Prof. Kamil Kamiński

Polymeric materials are redefining the future of pharmaceuticals - but our research makes one thing clear: commercial polymers simply are not enough. True innovation comes from designing precise macromolecular architecture, the key to boosting drug solubility, bioavailability, and stability.

During the VINCI workshops, you will learn how to design and synthesize unique polymers using innovative pressure- and light-assisted methods, tailoring their structures to specific active pharmaceutical ingredients. These advanced materials will then serve as efficient matrices for drug–polymer mixtures, thoroughly examined with various techniques (DSC, XRD, BDS, UV-Vis).

Through the NAWA VINCI program, you can join our team, gain hands-on experience in polymer and drug chemistry, and build skills vital for the chemical, pharmaceutical, and materials industries. Shape the future of polymer-based drug design with us.

12. Drugs in the Diamond Trap: High-Pressure Spectroscopic Studies of Active Pharmaceutical Ingredients

Barbara Hachuła, PhD, DSc, Assoc. Prof.

Discover how extreme pressure reveals a hidden world of molecular transformations! In this workshop, you will explore how active pharmaceutical ingredients (APIs) undergo pressure-induced structural transformations — from polymorphism, amorphization, solvate or hydrate formation, co-crystallization, tautomerization to decomposition — and how these modifications affect drug stability, solubility, and therapeutic performance. Using a diamond anvil cell (DAC) and spectroscopic techniques such as infrared, Raman, and dielectric spectroscopy, you will observe real-time transformations, discover new polymorphs, and study phase transitions impossible to access under normal conditions. This knowledge is crucial, as tablet manufacturing involves the compression that can significantly alter or even degrade APIs. This workshop offers hands-on DAC experiments, data analysis training, and a solid introduction to high-pressure spectroscopy. Join me to uncover how compression shapes pharmaceutical materials and to experience a fascinating, unique dimension of matter under high pressure!

13. Beyond limits: designing intelligent polymers for next-generation biomedical materials

Roksana Wygoda, PhD, Eng.

In the NAWA Vinci program, you will learn how to design polymers with precise control over molecular weight, dispersity, and functionality. You will explore how external stimuli such as pressure, light, and spatial confinement can drive, speed up and control polymerization process, enhance conversion, and enable synthesis of materials unattainable under standard conditions. Working with advanced tools, including a unique photo-pressure reactor and Schlenk lines, you will gain hands-on experience in modern synthesis and polymer characterization (NMR, GPC, DSC, IR). You will also create smart, responsive biomaterials and translate laboratory discoveries into real biomedical applications. Being part of the NAWA Vinci program means gaining access to the equipment unavailable anywhere else and opportunity to work with experts in chemistry, physics, and materials science.

14. Sustainable Chemistry and Innovation from Natural Resources

Jacek Nycz, PhD, DSc Eng. Assoc. Prof.

This workshop introduces students to the potential of natural resources—biomass, agricultural residues, CO₂, wood, and food waste—as renewable feedstocks for modern, environmentally friendly technologies. Participants will explore real-world examples such as biodiesel production from vegetable oils or waste fats, bioplastics obtained from sugars, vanillin derived from lignin, and plant-based biosynthesis of metal nanoparticles. They will also learn about innovative materials like lignin-based composites with UV-shielding and antioxidant properties, green solvents, and nanostructured sensors for detecting heavy metals.

Key challenges will be addressed as well: energy efficiency of processing natural resources, competition with the food sector, stability of biomass supply under climate change, and strategies to reduce the use of toxic solvents through mechanical methods or supercritical CO₂ extraction.

The practical part consists of three modules:

- **Process Design** – Teams propose a method for obtaining a selected organic compound from local natural resources, considering environmental, economic, and social aspects.
- **Technology Comparison** – Simulation of traditional versus bio-based routes for producing a chosen chemical, followed by analysis of advantages and limitations.
- **Mini Eco-Hackathon** – Brainstorming innovative uses for agricultural waste, lignin, or process water to develop new materials, nanoparticles, or biodegradable products.

15. Exciting Nano world. Towards development of the unique nano drug delivery systems

Magdalena Tarnacka, PhD, DSc, Assoc. Prof.

Modern pharmaceutical science aims to enhance poorly soluble drugs by using nanotechnology. A promising method involves incorporating active ingredients into non-toxic, nanoporous membranes to improve bioavailability and enable prolonged release. This internship will study how nanoscale confinement within mesoporous silica or alumina (pores 4-160 nm) affects the molecular dynamics, crystallization, and potential polymorphism of antifungal drugs itraconazole and ketoconazole. Key tasks include planning experiments, synthesizing matrices, performing



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dielectric/calorimetric measurements, and analyzing data to understand drug behavior, which is critical for designing advanced drug delivery systems.