MoCuHer - MOLECULES IN CULTURAL HERITAGE

České Budějovice, 24.8.-29.8. 2026

August 24, Monday

L1

130 YEARS OF SEEING THE INVISIBLE: THE STORY OF X-RAY DISCOVERY

Pavlína Řezáčová

Institute of Organic Chemistry and Biochemistry, Czech Academy of Sciences, Flemingovo nam. 2, 16610 Prague, Czech Republic
rezacova@uochb.cas.cz

In November 1895, the German physicist Wilhelm Conrad Röntgen made a discovery that changed science and medicine. While working with a Lenard discharge tube in his laboratory at the University of Würzburg, he noticed something strange. Although the room was completely dark and the tube was covered with black cardboard, a screen coated with barium platinocyanide began to glow. Röntgen realized that invisible rays were coming from the tube and passing through the cardboard. He closed himself in the laboratory for seven weeks and soon discovered that these rays could pass through many materials, such as wood and paper, but were blocked by denser materials, such as lead and bone.

The most famous moment in this story happened on December 22, 1895, when Röntgen took the first medical X-ray image. For this experiment, he used the hand of his wife, Bertha Röntgen. When the image was developed, it clearly showed the bones of her hand and her wedding ring. Although, like many women in the 19th century, Bertha was an invisible supporter of her husband's career, this image made her famous. Through the picture of her hand, she became part of the history of science and medicine.

Röntgen quickly shared his results by sending copies of his paper "On a new kind of rays" [1], and photographs to scientists around the world on New Year's Day in 1896. News of this "sensational discovery" spread around the world very quickly. The Viennese newspaper Die Presse published the breakthrough on January 5, followed closely by British newspapers The Daily Chronicle and German Der Standard.

People were fascinated by the idea of "seeing the invisible." Because Röntgen chose not to patent his discovery, doctors and scientists everywhere could begin using X-rays almost immediately around the world. Interestingly, the first recorded medical use of X-rays in Australia dates to early 1896, when William Henry Bragg, then a professor at the University of Adelaide, used home-made equipment to produce an X-ray photograph of his six-year-old son's arm after a tricycle accident. Years later, the father and son collaborated to study how X-rays interact with crystals and in 1915, they were jointly awarded the Nobel Prize in Physics for their work.

Other well-known inventors, including Thomas Edison, also began developing X-ray devices such as the fluoroscope. However, this early period also revealed the dangers of radiation, including the tragic death of Edison's assistant, Clarence Dally, from radiation exposure. Röntgen received the first ever Nobel Prize in Physics in 1901. Today, X-rays are indispensable tools in medicine, industry, are and science.

This lecture is tailored for a general audience to make Röntgen's discovery accessible and engaging. It features a practical demonstration using props from the theatre play written by Pavlína Řezáčová and performed by the non-professional group Scéna Kralupy nad Vltavou[2].

1. Röntgen, W. (1895). Ueber eine neue Art von Strahlen. Vorläufige Mitteilung, Aus den Sitzungsberichten der Würzburger Physik.-medic. Gesellschaft Würzburg.

2.http://www.scenakralupy.cz/nase-hry/berta-rtg-jako-bych-videla-svou-smrt/.

L2

X-RAY TECHNIQUES IN STRUCTURAL BIOLOGY AND HERITAGE SCIENCE

Klaudia Hradil, Valentina Ljubć Tobisch

X-ray center, TU Wien, Wien, Austria
klaudia.hradil@tuwien.ac.at

Crystallography plays a central role in heritage science because it enables the minimally invasive or non-destructive characterization of cultural and natural heritage materials at the atomic and microscopic scales. For countries such as Austria and the Czech Republic, which share a rich cultural and industrial heritage, the targeted application of crystallographic methods is essential for preserving historical artefacts, monuments, and natural heritage while ensuring the efficient use of limited scientific and financial resources. Modern laboratory facilities, complemented by large-scale research infrastructures, provide a cost-effective and comprehensive analytical framework for heritage investigations.

The crystallographic toolbox includes single-crystal and powder X-ray diffraction (SCXRD and PXRD), pair distribution function (PDF) analysis, electron diffraction (ED), small-angle X-ray scattering (SAXS), X-ray fluorescence (XRF), and complementary spectroscopic techniques. Together, these methods reveal crystal structures, phase composition, degradation and corrosion processes, manufacturing technologies, and previous conservation treatments, thereby providing the scientific basis for sustainable conservation strategies and evidence-based restoration.

The following lecture will discuss the role of crystallography in heritage science, highlighting its scientific, cultural, and economic impact through selected examples from Austria and the Czech Republic, and demonstrating how complementary crystallographic methods contribute to the preservation and understanding of our shared cultural and natural heritage.

L3

ECOCULTURAL HERITAGE IN ENVIRONMENTAL CHANGE: ADAPTATION, AGENCY AND JUSTICE

Lucia Nováková[1], Silviu-Marian Miloiu[2]

[1]Department of Classical Archaeology, Trnava University in Trnava, Trnava, Slovakia
[2]Doctoral School, Faculty of Humanities, Valahia University of Târgovişte, Târgovişte, Romania
lucia.novakova@truni.sk

Heritage governance still separates cultural significance from ecological value, although places, practices and species often acquire meaning through the same relations. Ecocultural heritage is used here as a relational analytical framework for examining how ecological processes, cultural practices, institutions and material traces jointly produce heritage value. It differs from biocultural heritage, which foregrounds linked biological and cultural diversity, and from cultural landscape classifications, which remain bounded by particular administrative traditions. More-than-human heritage extends agency beyond people; ecocultural analysis asks how that agency enters decisions and with what consequences [1, 2].

This critical conceptual review examines when an ecocultural approach can connect climate adaptation, more-than-human agency and heritage justice without erasing institutional distinctions or local conflict. The review does not claim systematic coverage. Instead, it compares ontological assumptions, treatments of change and loss, forms of agency and implications for governance. The analysis also distinguishes theoretical propositions from policy commitments, management guidance and evidence of local implementation.

The synthesis identifies partial convergence rather than a single paradigm. Climate adaptation exposes the limits of preserving material fabric unchanged, yet decisions to transform a place or accept loss remain politically charged [3, 4]. Integration can reveal dependencies hidden by separate protection regimes, but it may also weaken specialised safeguards, blur institutional responsibility and conceal unequal interests beneath consensual language. More-than-human approaches widen the field of care, although recognising a river, forest or species as an actor does not determine who may represent it. Such representation requires transparent mandates, contestable evidence and accountable decisions [5, 6].

These problems become sharper when authority and justice are considered together. Western theory should not present long-standing Indigenous accounts of human-environment relations as a recent academic discovery [7]. Nor should Indigenous peoples or local communities be treated as unitary constituencies, since knowledge, authority and vulnerability are situated and may be disputed. Biocultural governance shows why community leadership matters, but participation alone does not settle conflicts between ecological integrity, cultural continuity and material authenticity [8]. Choices about protection, managed change or

relinquishment therefore require attention to who decides, who benefits and who bears cultural, social and material costs.

The proposed framework begins by specifying the object of care and the relations through which it gains significance. It then examines who can speak and decide, how benefits and burdens are distributed, and which assumptions govern adaptation or loss. Finally, it locates each claim at the level where it can be supported, separating conceptual argument from policy intent and demonstrated practice. Ecocultural integration is defensible only when it keeps conflicts visible, preserves necessary institutional protections and permits decisions to be revised as ecological and social conditions change. Under those conditions, it offers a rigorous basis for heritage management without turning relationality into an abstract promise of harmony.

1. Harrison, R. Beyond "natural" and "cultural" heritage: Toward an ontological politics of heritage in the age of the Anthropocene. *Heritage & Society* **8**, 24–42 (2015).
2. Palacio, R. D. & Goli, S. Bridging the nature–culture divide: A biocultural reclassification of the World Heritage Sites. *Ecology and Society* **30**, Art. 31 (2025).
3. Seekamp, E. & Jo, E. Resilience and transformation of heritage sites to accommodate loss and learning in a changing climate. *Climatic Change* **162**, 41–55 (2020).
4. Holtorf, C. Embracing change: How cultural resilience is increased by cultural heritage. *World Archaeology* **50**, 639–650 (2018).
5. Sterling, C. Critical heritage and the posthumanities: problems and prospects. *International Journal of Heritage Studies* **26**, 1029–1046 (2020).
6. Roudavski, S. & Rutten, J. Towards more-than-human heritage: Arboreal habitats as a challenge for heritage preservation. *Built Heritage* **4**, Art. 3 (2020).
7. Todd, Z. An Indigenous feminist's take on the ontological turn: "ontology" is just another word for colonialism. *Journal of Historical Sociology* **29**, 4–22 (2016).
8. Lyver, P. O'B. *et al.* Building biocultural approaches into Aotearoa–New Zealand's conservation future. *Journal of the Royal Society of New Zealand* **49**, 394–411 (2019).

L4

FROM THE BRAGGS TO BILL ASTBURY AND THE ADVENT OF MODERN STRUCTURAL MOLECULAR BIOLOGY

Tomáš Bílý[1,2], David Kaftan[2,3], Jakub Pšenčík[4], Rebecca F. Thompson[5], Roman Tůma[1,5]

[1]Faculty of Science, University of South Bohemia, Czech Republic
[2]Institute of Parasitology, Czech Academy of Sciences, Czech Republic
[3]Institute of Microbiology, Algatech, Czech Academy of Sciences, Czech Republic
[4]Faculty of Mathematics and Physics, Charles University, Czech Republic
[5]Astbury Centre for Structural Molecular Biology, University of Leeds, United Kingdom

The Bragg law underpins interpretation of X-ray diffraction patterns of crystals as well as other partially ordered systems. We will first turn back the clocks to the beginning of the 20th century and look at the early developments of X-ray diffraction and its connection to the University of Leeds where the data underpinning the famous law were collected. Subsequently, Bill Astbury was recruited to the University of Leeds to take over the Bragg legacy and applied X-ray diffraction to textiles. We will discuss how this work fundamentally contributed to the study of biological material and paved way to the discovery of DNA structure. In the end we will return to the present day Astbury Biostructure Laboratory and illustrate the complementarity of X-ray scattering and electron cryo-microscopy in the study of partially ordered biological assemblies.

1. Jenkin, John. William and Lawrence Bragg, Father and Son: The Most Extraordinary Collaboration in Science. OUP Oxford, 2008.
2. Hall, Kersten T. The Man in the Monkeynut Coat: William Astbury and How Wool Wove a Forgotten Road to the Double-Helix. OUP Oxford, 2014.
3. Tomáš Bílý, David Kaftan, Rebecca F. Thompson, David Řeha, Jakub Pšenčík, Roman Tuma (2026) Planar arrangement of bacteriochlorophyll *c* aggregates in chlorosomes of *Chloroflexus aurantiacus.* Biophys. J., **125**, 1494-1505..

August 25, Tuesday

L5

CELLULAR SECRETS UNVEILED: EVER WONDERED WHAT YOUR CELLS ARE UP TO AT NIGHT?

K. Teznerová

Altium International s.r.o., Na Jetelce 69/2, 190 00 Praha 9

In recent years, digital holographic microscopy (DHM) has gained widespread popularity as a convenient and reliable tool for observing cell populations. Its user-friendly, fully automated workflow enables long-term, label-free imaging without the need for chemical stains or fluorescent labels, which can introduce unwanted cytotoxic effects and interfere with normal cellular behavior. By combining quantitative phase imaging with non-invasive data acquisition, DHM provides high-quality images while preserving the natural characteristics and dynamics of living cells.

This gentle imaging approach eliminates the need for disruptive sample preparation and allows continuous observation of cells with high spatial and temporal resolution. As a result, even subtle changes in cell morphology, growth, migration, and proliferation can be accurately captured and quantified over extended periods.

By enabling real-time monitoring of cellular processes in their native environment, DHM offers an innovative platform for long-term live-cell imaging. Its ability to provide quantitative, label-free measurements with minimal disturbance to the sample has opened new opportunities for studying complex biological processes and has made DHM an increasingly valuable tool in fields such as cell biology, microbiology, cancer research, drug discovery, and tissue engineering.

L6

tRNA IN THE HISTORY OF MOLECULAR AND STRUCTURAL BIOLOGY

Claude Sauter

Institut de Biologie Moléculaire et Cellulaire (IBMC), CNRS, University of Strasbourg (Unistra), France
c.sauter@ibmc-cnrs.unistra.fr

Transfert RNAs or tRNAs are central actors of the translational machinery, playing the role of adapter molecules in mRNA decoding by the ribosome during protein synthesis. Their existence was first hypothesised by Francis Crick in 1955 to explain how to go from a genomic message coded in four letters (the nucleotides that make up DNA and RNA) to a polypetidic sequence of twenty letters (the amino acids). tRNAs were the first RNAs whose structure was investigated by X-ray crystallography and long remained the only source of 3D information on RNA [1]. They carry an astonishing diversity of chemical modifications that modulate their stability and functions. Indeed, they participate in many other cellular processes such as gene regulation, amino acid and cell wall biosynthesis, initiation of reverse transcription of viral genomes, etc. This exploration of tRNA biology—from their discovery to recent developments—will provide an overview on this fascinating family of small RNAs and illustrate their unique place in the history of molecular and strucural biology.

1. Fernández-Millán, P. *et al*. *Archives of Biochemistry and Biophysics* **602**, 95–105 (2016).

L7

MOLECULAR APPROACHES FOR THE AUTHENTICATION AND PRESERVATION OF TURKISH GEOGRAPHICAL INDICATION FOODS AS CULTURAL HERITAGE

Begüm Zeynep Hancerliogullari, Hasim Kelebek

Department of Food Engineering, Faculty of Engineering, Adana Alparslan Türkes Science and Technology University, 01250 Adana, Türkiye

Traditional foods protected by geographical indication (GI) status represent an important part of Türkiye's cultural heritage, reflecting regional biodiversity, traditional knowledge, and local production practices. However, increasing concerns about food fraud, adulteration, and mislabeling highlight the need for reliable scientific approaches to support the authenticity and traceability of these products.

This presentation provides an overview of current molecular approaches used for the authentication and preservation of Turkish GI foods. DNA-based methods, including DNA barcoding, molecular markers, quantitative PCR, and next-generation sequencing, enable accurate species identification, origin verification, and adulteration detection. In addition, emerging RNA-based approaches offer complementary insights into microbial activity, fermentation processes, and product quality.

The presentation will discuss how molecular tools, together with emerging foodomics approaches, contribute to safeguarding culinary heritage by strengthening food authenticity, traceability, consumer confidence, and quality assurance. Future perspectives on the application of foodomics for the sustainable preservation of traditional foods will also be highlighted.

August 26, Wednesday

L8

PROTEIN PURIFICATION IN AND BEYOND THE CRYSTALLOGRAPHY WORLD

Sergio Martínez-Rodríguez

Department of Biochemistry and Molecular Biology III and Inmunology, University of Granada
sergio@ugr.es

Protein purification is a critical prerequisite for biochemical, biophysical, and structural analyses [1]. However, these biomolecules are also used at different purity levels in economic sectors such as pharmaceuticals, human health or feed industry, also becoming part of the cultural heritage of different regions/countries (e.g., enzymes used in food-making). Furthermore, protein purification is key in cultural heritage methodologies, such as paleoproteomics, allowing to decipher cultural heritage secrets [2,3]. In this talk, we will summarize different protein production/purification methodologies commonly associated with the structural biology world, which have also been embraced by cultural heritage studies.

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2. Giuffrida, M.G., Mazzoli, R. & Pessione, E. (2018). Appl Microbiol Biotechnol 102, 5445–5455.
3. Bertrand, C. et al. (2025). J. Cult. Heritage, 75:122–138.

L9

THE ROLE OF PROTEIN CRYSTALS IN BIOTECHNOLOGY AND PHARMA

José A. Gavira

Laboratorio de Estudios Cristalográficos, IACT-CSIC, Avd. las Palmeras, 4, 18100 Armilla, Spain
j.gavira@csic.es

The crystallization of biomolecules has played a pivotal role in pharmaceutical innovation, with insulin being the first hormone successfully crystallized to obtain a pure and stable form that transformed diabetes treatment and improved the lives of millions of patients, its crystallization not only enabled large-scale purification and stabilization, but also established the foundation for modern protein-based therapeutics (Figure 1). Building on this legacy, protein crystals have become essential tools for diverse applications ranging from structural biology to advanced drug delivery. In the field of biocatalysis, enzymes exploit their versatility, selectivity, and specificity to catalyze industrially relevant reactions under mild conditions. To extend their lifetime under extreme conditions and enhance efficiency, enzymes can be immobilized in different supports, with Cross-Linked Enzyme Crystals (CLECs) offering one of the most robust and recyclable solutions [1]. CLECs are currently experiencing a renaissance, boosted by advances in protein crystallization over the last two decades and by the development of novel scaffold materials. In this lecture, I will present how knowledge gained from crystallization in convection-free environments has been applied in our lab to produce protein crystals for biotechnological applications, including: i) CLECs for the development of enhanced, robust biosensors [2], ii) reinforced cross-linked enzyme crystals (rCLECs) for large-scale enzymatic reactions with durable auto-supported catalysts [3], and iii) reinforced protein crystals for controlled drug delivery systems [4].

Figure 1. In May 1921, Fredrick Banting met in John Macleod's lab to begin their experiments with insulin. In January 1922, the first person received an insulin injection. By 1923, insulin was commercially available. Banting and Macleod received the 1923 Nobel Prize in medicine.

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2. Conejero-Muriel, M., eta al., *Anal Chem* **88**, 11919–11923 (2016).
3. Fernández-Penas, R., et al., *Cryst Growth Des* **21**, 1698–1707 (2021).
4. Contreras-Montoya, R. *et al. ACS Appl Mater Interfaces* **13**, 11672–11682 (2021).

L10

NUCLEATION UNDER CONFINEMENT: FROM SALT WEATHERING TO BIOMOLECULAR PHASE TRANSITIONS

Isaac Rodríguez-Ruiz

Laboratoire de Génie Chimique de Toulouse (LGC-CNRS), France
isaac.rodriguez-ruiz@cnrs.fr

Confinement can act both as a physical constraint and as an experimental strategy for investigating nucleation mechanisms that remain difficult to access in conventional bulk experiments. By modifying nucleation probability, transport phenomena, and the accessible range of supersaturations, confined environments enable the exploration of thermodynamic and kinetic regimes that are rarely reached at larger scales. As a result, they provide a unique framework for examining how phase-transition pathways evolve under increasingly constrained and out-of-equilibrium conditions. Despite the apparent differences between inorganic and biomolecular materials, common physical principles often emerge when nucleation is examined at small scales.

This lecture will first introduce the fundamental effects of confinement on nucleation dynamics before illustrating these concepts through examples drawn from microfluidic studies of crystallization and phase transitions. Particular emphasis will be placed on the ability of droplet-based microfluidics to isolate individual nucleation events, access highly metastable states, and generate statistically significant datasets under well-controlled conditions. To illustrate the broad applicability of these concepts, examples will then be drawn from microfluidic investigations of both inorganic crystallization and biomolecular phase transitions.

The first example will focus on inorganic salt crystallization in evaporating microdroplets. Under confinement, evaporation-driven concentration enables the exploration of extreme supersaturation conditions that are rarely achieved in macroscopic experiments. Studies of sodium chloride crystallization will be discussed as model systems for understanding nucleation under strong confinement, with implications for salt weathering processes and the deterioration of porous materia1s [1, 2]. Additional examples will illustrate how microfluidic approaches can provide mechanistic insights into crystallization pathways in inorganic systems.

The discussion will subsequently turn to biomolecular phase transitions through the study of lysozyme crystallization pathways across its phase diagram. Taking advantage of confinement and high-throughput microfluidic approaches, these studies provide a continuous picture of the crystallization process, linking intermolecular protein interactions and early association events to liquid-liquid phase separation and the emergence of distinct nucleation mechanisms under increasingly out-of-equilibrium conditions. Particular attention will be given to the transition from classical crystallization regimes to conditions where non-classical pathways become dominant [3].

Together, these examples highlight how the study of nucleation under confinement provides a common physical perspective on phase transitions across systems, linking questions that range from the deterioration of cultural heritage materials to the molecular origins of biomolecular self-assembly.

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[3] Karibjanova, *et al.* Microfluidics resolves non-classical lysozyme nucleation driven by attractive protein interactions. *Journal of Molecular Liquids*, **447**, 129378 (2026).

L11

FROM PETROLEUM-BASED PLASTICS TO BIOFILMS: A JOURNEY THROUGH THE MOLECULAR HERITAGE OF PLASTICS TOWARD A MORE SUSTAINABLE LIFESTYLE

Guillermo Escolano-Casado, Vedran Milosavljevic

Chemistry and Biochemistry Department, Mendel University, Brno, Czech Republic
guillermo.casado@mendelu.cz

Since their large-scale introduction during the past century, petroleum-based synthetic plastics (PBSP) have become essential for modern life. Their presence is ubiquitous in all daily products and industries as materials for packaging, merchandising, construction, electronics, transportation, and health care, which is possible thanks to their unique properties: light weight, chemical inertness, mechanical versatility and, above all, low-cost production. However, PBSP overproduction carries a heavy molecular legacy. It is estimated that of the millions of tonnes of plastics produced to date, only around 9% has been recycled, 79% has accumulated in the natural environment, and 12% has been incinerated [1]. From a chemical point of view, PBSP are polymers derived from fossil hydrocarbons such as polyethylene, polypropylene and poly(ethylene terephthalate). Consequently, PBSP are essentially non-biodegradable, and persist in nature as micro- and nanoplastics, producing direct ecological and health consequences for living beings. For such reasons, this problem can be considered the starting point of the molecular heritage of plastics, from PBSP towards the novel bio-based polymers proposed to replace them. The final target is to use films from plant-based biopolymers (bioplastics) that ensure a green future while maintaining industry requirements. The bioplastics alternative rests on three broad families: microbial polyesters obtained by fermentation, bioplastics polymerised from renewable monomers (corn or sugarcane monomers), and naturally occurring biopolymers, chiefly polysaccharides or proteins, that already possess intrinsic film-forming ability [2]. In particular, polysaccharides from plant- and marine-derived sources combine natural abundance, biodegradability, biocompatibility and inherent capacity to form biofilms. These bioplastics generally exhibit strong barrier properties against atmospheric gases (O_2, CO_2), but unfortunately, their hydrophilic character limits moisture resistance and mechanical properties (strength, elongation at break, Young's modulus) [3] . Therefore, the bioplastic structural units must be modified to reach the performance characteristics of PBSP. There are two possible ways of modification. The first is physical, based on composite and blend strategies, i.e. combining polysaccharides with proteins or lipids and adding plasticisers. The second is chemical, based on the targeted modification of the biopolymer backbone: crosslinking,

oxidation, esterification, amidation and grafting reactions that tune hydrophobicity, mechanical response and reactivity. Moreover, the modification strategy can also be addressed toward the incorporation of active agents (essential oils, polyphenols and/or nanoparticles), either physically or chemically, with the aim of obtaining the desired structurally reinforced bioplastics that also show specific functionalities, such as antimicrobial or antioxidant properties. Consequently, at the final step, research moves toward the production of active and stimuli-responsive bioplastics, tailoring the chemical modification according to the future applications of the bioplastics. In summary, by adjusting classical chemical modifications to more sustainable methodologies and applying them to the reinforcement and improvement of the properties of the natural biopolymers, the molecular heritage of plastics can be redirected from an environmental burden to a more sustainable lifestyle.

1. R. Geyer, J.R. Jambeck, K.L. Law, Production, use, and fate of all plastics ever made, *Science advances* **3**, e1700782 (2017).
2. A.Z. Naser, I. Deiab, B.M. Darras. Poly (lactic acid)(PLA) and polyhydroxyalkanoates (PHAs), green alternatives to petroleum-based plastics: a review. *RSC advances* **11**, 17151-17196 (2021).
3. P. Cazón, G. Velazquez, J.A. Ramírez, M. Vázquez, Polysaccharide-based films and coatings for food packaging: A review. *Food hydrocolloids* **68**, 136-148 (2017).

August 28, Friday

L12

GREEN NANOTECHNOLOGY IN CULTURAL HERITAGE: PLANT-BASED NANOPARTICLE COATINGS AS PROTECTIVE LAYERS

Kanika Dulta[1,2], Nidhi Bhardwaj[2,3], Vedran Milosavljevic[1], Lukas Peter[2]

[1]Department of Chemistry and Biochemistry, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
[2]Faculty of Materials Science and Technology, VŠB – Technical University of Ostrava, Czech Republic
[3]Department of Chemistry, Faculty of Science, University of Hradec Kralove, Rokitanskeho 62, 500 03, Hradec Kralove, Czech Republic
kanikadulta10@gmail.com

The surging demand for sustainable post-harvest preservation technologies has advanced the development of green nanotechnology-based coating systems with advanced antimicrobial and protective functionalities. However, the recent advances in plant-mediated synthesis of nanoparticles (NPs) have evolved as an environmentally friendly, sustainable approach, and cost-effective, which utilizes naturally occurring phytochemicals as reducing, capping, and stabilizing agents. In addition, the biogenic NPs offer superior antioxidant, antimicrobial, and barrier properties, which enhance the potential for multifunctional food preservation utilization. Therefore, postharvest deterioration caused by microbial contamination, environmental stress, and oxidative degradation remains a major challenge that affects the safety, shelf life, and quality of fresh agro-based materials. Whereas, to address such limitations for biodegradable nanocomposite coatings, which incorporate metal oxide NPs within natural polymer matrices, has received considerable attention. The plant-derived zinc oxide (ZnO) NPs exhibit broad-spectrum antibacterial activity with enhanced compatibility with biopolymer coatings. Thus, this enhances the microbial inhibition and preserves product quality [1]. Additionally, copper oxide (CuO) NPs possess significant photocatalytic properties that contribute to the development of multifunctional coatings with improved preservation efficiency and durability [2]. Furthermore, natural biopolymers, which include alginate and chitosan, provide ideal matrices for NPs incorporation due to their better film-forming ability, biocompatibility, biodegradability, and inherent antimicrobial characteristics. Thus, the recent studies exhibited that ZnO NPs-incorporated with chitosan coatings can significantly improves antimicrobial performance and extend the storage life of fresh produce [3]. Similarly, alginate-chitosan nanocomposite coatings enriched with ZnO NPs effectively reduce microbial spoilage, which preserves the physicochemical characteristics and enhances the postharvest quality of fruits and vegetables [4].

In addition, the synergistic integration of plant-synthesized metal oxide NPs with biodegradable polymeric coatings represents a promising pathway for the development of next-generation sustainable preservation systems. Therefore, these green nanocoatings provide an eco-friendly solution to conventional preservation techniques by minimizing post-harvest losses and enhancing food safety by extending shelf life and reducing environmental impact. Thus, future research mainly focuses on comprehensive toxicity assessments, regulatory considerations, scalable manufacturing, and long-term stability studies to facilitate the safe commercialization of these sustainable nanocoating technologies.

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eggplant (*Solanum melongena* L.). *Food Control* **168**, 110912 (2025).

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3. Dulta, K. *et al.* Development of alginate–chitosan-based coating enriched with ZnO nanoparticles for increasing the shelf life of orange fruits (*Citrus sinensis* L.). *J. Polym. Environ.* **30**, 3293–3306 (2022).
4. Dulta, K. *et al.* A novel approach of synthesis zinc oxide nanoparticles by *Bergenia ciliata* rhizome extract: antibacterial and anticancer potential. *J. Inorg. Organomet. Polym. Mater.* **31**, 180–190 (2021).

L13

TAILORED LASER-INDUCED GRAPHENE FROM NANOCOMPOSITE THIN FILMS

Vitezslav Stranak[1], Abel Koshy[1], Alexej Horak[1], Franciszek Skiba[2], Mateusz Szala[3], Milan Dopita[4], Robert Bogdanowicz[2]

[1]University of South Bohemia, Branisovska 1760, 37005 Ceske Budejovice, Czechia
[2]Gdańsk University of Technology, 11/12 Narutowicza St., 80-233 Gdańsk, Poland
[3]Military University of Technology, ul. Gen. Sylwestra Kaliskiego 2, Warsaw, Poland
[4]Charles University in Prague, Ke Karlovu 5, 121 16 Prague, Czech Republic
stranak@prf.jcu.cz

Laser-induced graphene (LIG) has emerged as an attractive material for electrochemical sensing owing to its high electrical conductivity, large specific surface area, and porous morphology. The performance of LIG, however, is strongly influenced by the chemical composition and microstructure of the precursor material. In this work, nanocomposite polyimide thin films prepared by RF magnetron sputtering were employed as tailored precursors for laser-induced graphitization. Optimization of the plasma deposition process enabled preservation of essential molecular motifs, including aliphatic groups and partially retained polymer backbone structures, promoting efficient laser-induced carbonization.

The chemical composition of the deposited films was characterized by FTIR and NMR spectroscopy prior to laser processing. Raman spectroscopy confirmed the successful formation of multilayer graphene, with I(D)/I(G) and I(2D)/I(G) intensity ratios indicating controlled graphitic ordering and defect density. SEM observations further revealed a highly porous, interconnected network favorable for electrochemical applications.

To extend the functionality of the resulting LIG, two nanocomposite approaches were investigated. Fluorine was incorporated by co-sputtering PTFE, while Cu nanoparticles produced using a gas aggregation source were embedded into the precursor films during deposition. The nanoparticle size distribution, concentration, and spatial uniformity were quantitatively analyzed by small-angle X-ray scattering (SAXS). Both modification strategies enabled systematic tuning of the electronic properties of the laser-induced graphene, leading to enhanced carrier concentration and improved charge transport. These results demonstrate that plasma-deposited nanocomposite thin films provide a versatile platform for engineering functional LIG electrodes for next-generation electrochemical sensing.

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L14

EXPLORING THE MORPHOLOGY AND STRUCTURE OF Fe-BASED NANOMATERIALS FOR PHARMACEUTICAL APPLICATIONS USING X-RAY SCATTERING METHODS

Milan Dopita

Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, 121 16 Praha 2

Iron carboxymaltose (ICM) is an intravenous iron formulation in which ferric hydroxide nanoparticles are stabilized by a carboxymaltose shell. Understanding its internal architecture is essential for elucidating the structure–property relationships that govern its stability and bio-av ailability. In this study, the microstructure of ICM was investigated using small-angle X-ray scattering (SAXS) and X-ray diffraction (XRD).

XRD analysis indicated that the iron core consists of nanocrystalline akaganeite (-FeOOH). The diffraction patterns exhibited broad reflections characteristic of a poorly crystalline, nanoscale material, confirming the nanocrystalline nature of the iron oxyhydroxide core.

SAXS analysis revealed a core–shell morphology comprising nanometer-sized iron oxyhydroxide cores surrounded by a disordered carbohydrate shell, consistent with a colloidal nanoparticle system. The scattering profiles were successfully fitted using a model consisting of two lognormally distributed spherical particle populations combined with a hard-sphere structure factor, revealing a bimodal particle size distribution. The larger particle population exhibited mean diameters of approximately 10–15 nm, whereas the smaller particle population had mean diameters of approximately 3.5–5 nm.

The combination of SAXS and XRD provides complementary morphological structural and microstructural information, demonstrating that ICM consists of nanocrystalline iron oxyhydroxide domains embedded within an amorphous polysaccharide matrix. These findings contribute to a deeper understanding of the physicochemical stability of ICM and the structural features governing its controlled iron release in vivo.

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INTERNATIONALISATION IN ACTION: TRNAVA UNIVERSITY'S STRATEGY AND ENGAGEMENT IN THE KREATIVEU ALLIANCE

Mária Hercegová

Trnava University in Trnava, Department for External Relations and Cooperation, Slovak Republic
maria.hercegova@truni.sk

Internationalisation is one of the key strategic priorities of Trnava University in Trnava (TRUNI). Based on an institutional audit, its 2025-2030 strategy seeks to embed an international dimension across education, research, mobility, services, and cooperation with society. This contribution presents how the strategy is being translated into practice through TRUNI International and participation in the KreativEU - Knowledge & Creativity European University Alliance.

The strategy combines measurable targets with institutional development. Its priorities include a stronger International Relations and Mobility Office, a physical and virtual TRUNI Hub, the TRUNI Forum for international academic dialogue, sustainable and inclusive mobility, improved support for international researchers, more courses and programmes in English, hybrid learning, micro-credentials, joint degrees, and systematic monitoring. By 2030, TRUNI aims to increase student and academic staff mobility by 30%, administrative staff mobility by 20%, and international research projects by 25%, while expanding English-taught provision and strengthening mutual recognition within KreativEU.

These goals build on an established international base. In 2024/25, 216 TRUNI students and employees participated in mobility abroad and 139 international students and employees came to TRUNI; the university cooperates with more than 200 partner institutions. Within KreativEU, this bilateral network is being developed into more structured, interdisciplinary, and alliance-wide collaboration. Activities include Blended Intensive Programmes, summer schools, teaching and training mobilities, joint seminars, student participation, hybrid formats, and networking among universities, cultural organisations, and regional stakeholders. Cultural heritage serves as an especially productive bridge between disciplines. The Heritage Game seminar hosted by TRUNI in 2025 brought together more than 60 participants from seven countries to explore gamification and community-based heritage work. The MoCuHer BIP similarly connects scientific training, cultural heritage, intercultural exchange, and institutional cooperation.

The contribution argues that KreativEU functions as an accelerator of TRUNI's internationalisation strategy: it broadens access to international experience, supports internationalisation at home, and links mobility with curriculum development, research collaboration, and societal engagement. It also identifies the next implementation priorities: embedding alliance opportunities across all faculties, ensuring inclusive participation, recognising learning outcomes, supporting staff capacity, and using evidence-based monitoring to turn individual activities into sustainable institutional