



2nd Annual Conference

Future Frontiers

PhD Conference on
Emerging Technologies

Book of Abstracts

2026

Institute of Technology
University of Tartu



An inter-institutional PhD conference

Ülikoolidevaheline doktorantide konverents

Welcome to the "Future Frontiers: PhD Conference on Emerging Technologies"!

This inter-institutional conference is designed for PhD students and their supervisors in **engineering, biotechnology, chemistry, physics, and materials science**. The two-day event will take place from **May 5 to 6, 2026**, in the charming student city of **Tartu, Estonia**.

Participation offers many early-career doctoral students their first conference experience, allowing them to present their research to an interdisciplinary audience and promoting collaboration among universities. The conference emphasizes applying scientific research to develop innovative technologies.

The event is organized by the Institute of Technology at the University of Tartu, in collaboration with the Estonian Doctoral School for Engineering and Technology.



The event is organized from the project "*Cooperation between universities to promote doctoral studies*" (2021-2027.4.04.24-0003), which is co-funded by the European Union.



Future Frontiers: PhD Conference on Emerging Technologies 2026
Book of Abstracts
Scientific Committee: Assoc. Prof. Margit Mutso and Ingrid Rebane
Compiled and Edited by Ingrid Rebane

Speakers

Eeskõnelejad

KEYNOTE SPEAKER



Luísa Czamanski Nora, PhD

Head of Strain Engineering at ÄIO

JOINT PLENARY TALK



Jan Janke, PhD

Head of Business Computing at CERN



Matthias Bräger, PhD

Software Engineer at CERN

Conference Venue

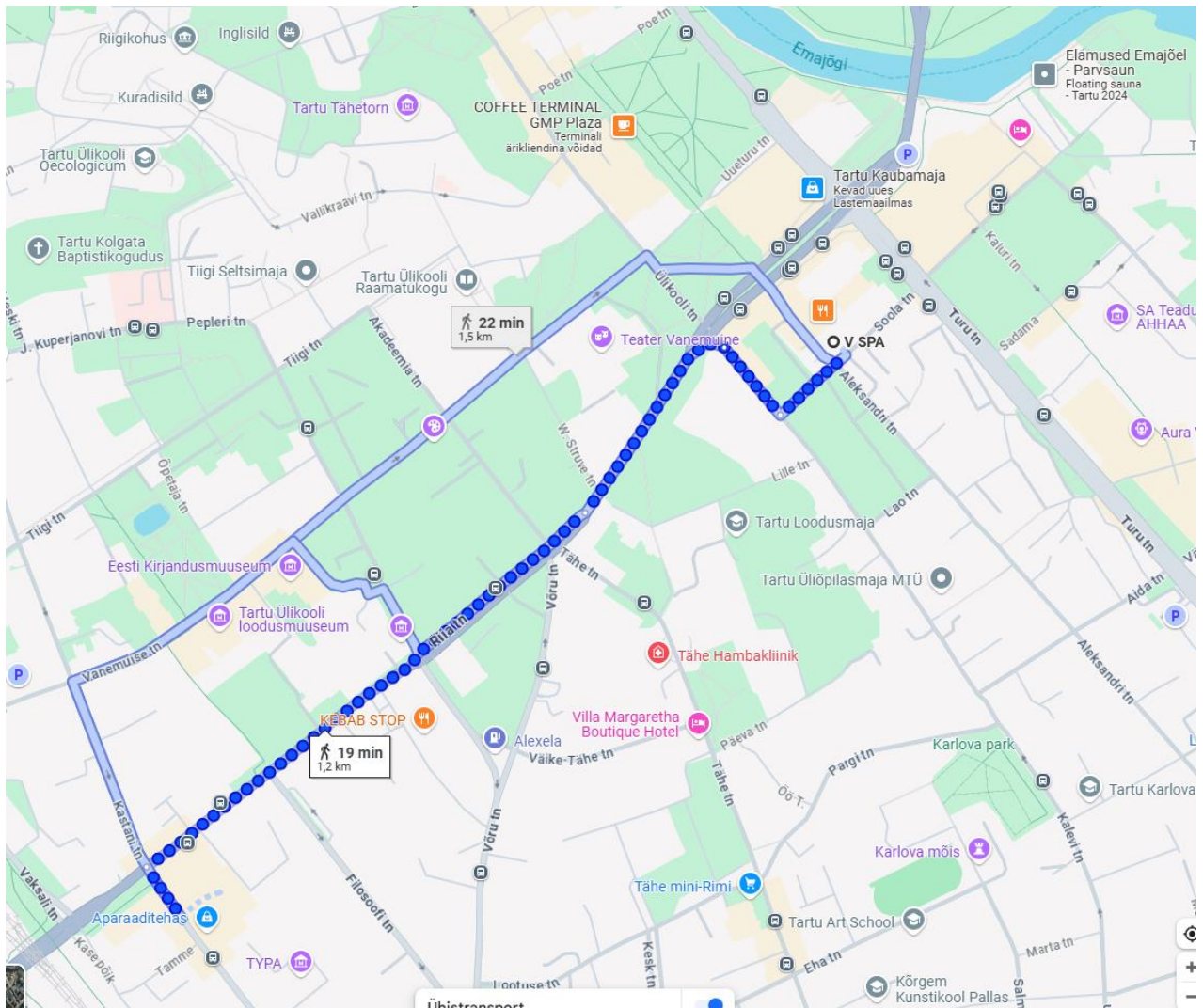
Konverentsi toimumiskoht

Day 1 and Day 2 conference sessions:

[V Spa Konverentsikeskus](#), Riia 2, Tartu, Estonia
(access from Aleksandri Street)

Evening Event on May 5th, 18:00-23:59

[Väike Till Sündmuskeskus](#), Kastani 42
(Aparaaditehas block, access from Kastani street)



Conference Schedule – Day 1

May 5, 2026

09:30	Welcoming & Registration, Coffee & Installing Posters		
10:45	Conference Opening by Prof. Reet Kurg , Head of the Institute of Technology, UT		
11:00	Keynote Speaker - Luísa Czamanski Nora, PhD Head of Strain Engineering, ÄIO		
11:45	ORAL SESSION 1 Valorization and Innovation		
	Cansu Özcan Kılcan, UT	Oral 1	Led by Anna-Liisa Peikolainen, Research Fellow in Materials Technology
	David Uslar, UT	Oral 2	
	Kati Muldma, TalTech	Oral 3	
	Kristi Rõuk, TalTech	Oral 4	
	Liis Tiivelt, UT	Oral 5	
13:00	Lunch		
13:45	ORAL SESSION 2 Materials Chemistry		
	Irina Petrotšenko, TalTech	Oral 6	Led by Livia Matt, Research Fellow in Organic Chemistry
	Karl Jakob Levin, UniTartu	Oral 7	
	Violetta Umerenkova, Taltech	Oral 8	
	Ermo Leuska, UniTartu	Oral 9	
	Shrikant Shivaji Pawade, UniTartu	Oral 10	
	John Paulo Samin, UniTartu	Oral 11	
15:15	Coffee break		
15:30	POSTER SESSION A led by Prof. Reet Kurg	P1-P4	
15:45	ORAL SESSION 3 Plants and Biology		
	Pranya Nepoliyan, UniTartu	Oral 12	Led by Ingmar Tulva, Research Fellow in Plant Physiology
	Minhal Abdullah, UniTartu	Oral 13	
	Patricia Kika Obinwanne, UniTartu	Oral 14	
	Ekaterina Ponamareva, UniTartu	Oral 15	
17:00	Concluding Day 1	Free time before dinner	
18:00	Evening program at Väike Till Sündmuskeskus		
	"BETWEEN TWO EVILS" Panel Discussion on Research and Entrepreneurship Aleksander Tõnnisson, Gary Urb (UP Catalyst), Liis Tiivelt (KIUD Technologies), Tarmo Tamm (UT Research and Industrial Collaborations)		
	Dinner and Social Program Evening elevated by Ritu, Normunds, and DJ BRAYAN FRIMBERG		

Conference Schedule – Day 2

May 6, 2026

09:00	ORAL SESSION 4 Navigation and Networks		
	Simon Idoko, UT	Oral 16	Led by Arun Kumar Singh, Professor of Motion Planning
	Aamir Latif, TalTech	Oral 17	
	Mir Mohibullah, UT	Oral 18	
	Edvin Martin Andrejev, UT / EAA	Oral 19	
10:00	Coffee Break		
10:15	POSTER SESSION B by Assoc. Prof. Taavi Lehto		P5-P10
11:00	JOINT PLENARY TALK: “Exploring CERN: Physics, Software, and Your Future” Jan Janke, PhD , Head of Business Computing at CERN Matthias Braeger, PhD , Software Engineer at CERN		
12:00	ORAL SESSION 5 Energy and Materials		
	Saqib Ali, TalTech	Oral 20	Led by Veronika Zadin, Professor of Materials Technology
	Hesham Ali, TalTech	Oral 21	
	Roni Koitermaa, UT	Oral 22	
12:45	Lunch		
13:30	ORAL SESSION 6 Social Robotics		
	Farnaz Baksh, UT	Oral 23	Led by Indrek Must, Associate Professor of Soft Robotics
	Igor Rybalskii, UT	Oral 24	
	Akbar Anbar Jafari, UT	Oral 25	
	Renno Raudmäe, UT	Oral 26	
14:30	Coffee Break		
14:45	POSTER SESSION C by Assoc. Prof. Ebe Merilo		P11-P17
15:30	ORAL SESSION 7 Biomedicine		
	Obedoulaye Boukary, UT	Oral 27	by Tõnis Lehto, Research Fellow in Nanobiotechnology
	Mihkel Suija, UT	Oral 28	
	Prachi Madan Garade, Taltech	Oral 29	
	Paule Hermet-Teesalu, UT	Oral 30	
	Lama Allan Abusamra, TLU	Oral 31	
16:45	Final words by Tarmo Tamm, Professor of Materials Engineering, Program Director for Engineering and Technology at UT		
End of the Future Frontiers PhD Conference Program			

Poster Session Schedule

DAY 1			
POSTER SESSION A			P1-P4
15:30 – 16:00	Siim Koor, UT	P1	Led by Prof. Reet Kurg
	Raimonds Makars, UT	P2	
	Victoria Prins, UT	P3	
	Normunds Berzins, UT	P4	
DAY 2			
POSTER SESSION B			P5-P10
10:15 – 11:00	Biswadeep Manna, TalTech	P5	Led by Assoc. Prof. Taavi Lehto
	Jagadeesh Kumar Reddy Mutra, TalTech	P6	
	Ireene Roman, UT	P7	
	Saqi Hussain, UT	P8	
	Elyad Damerchi, UT	P9	
	Ismail Sarigül, UT	P10	
POSTER SESSION C			P11-P17
14:45 – 15:30	Ritu Ghosh, UT	P11	Led by Assoc. Prof. Ebe Merilo
	Siim Heering, UT/EAA	P12	
	Elena Ivandi, UT	P13	
	Iris Robyn, UT	P14	
	Aishe Khalilova, TalTech	P15	
	Ausma Ul Hosna Shikha, UT	P16	
	Lisbeth Verk, UT	P17	

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ORAL ABSTRACTS

ORAL 1

Enhancing Life Cycle Impact Assessment of Natural Radioactivity in Construction Materials

[Cansu Özcan Kılcan](#)¹, Alan Henry Tkaczyk¹

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The growing interest in circular economy strategies for the construction materials leads to the incorporation of naturally occurring radioactive material (NORM) residues and by-products from different industries. While such practices reduce greenhouse gas emissions and support recycling, they may unintentionally elevate risks due to natural radioactivity. However, the consequences of this natural radioactivity have partly been incorporated into standard LCA models which often focus on the climate change impacts. To address this critical gap, we advanced the method of the original LCA-NORM framework co-developed by the research group, and we implemented this advanced method in a newly developed open-source Python package NORMIA. Our research presents a significantly improved life cycle impact assessment (LCIA) methodology that integrates NORM-related human health and ecological impacts into construction material life cycles from cradle to use scope. The advancements include revised characterization factor units aligned with international radiation protection standards, harmonized and updated use-stage exposure scenarios based on EN 17637, the integration of occupational inhalation exposure pathway, and updated key parameters such as effective dose conversion coefficients (DCCs). As the digital tool to run the advanced NORM LCIA method, NORMIA generates the characterization factors tailored to construction materials based on user-defined inputs such as material type and density. NORMIA enables the integration of custom elementary flows such as material radioactivity concentrations and fugitive naturally occurring radionuclide (NOR) emissions into conventional LCA models with an interactive approach. We ultimately aim to deliver a holistic and accurate assessment by fully integrating natural radioactivity into the environmental LCA of construction materials. Future developments may concentrate on further improving the practicality of NORMIA for both industry and research, broadening its applicability and impact.

Keywords: life cycle assessment, LCA, LCA-NORM, naturally occurring radioactive material, natural radioactivity

Acknowledgement: The research leading to these results was performed within the ReActiv project and received funding from the European Union Horizon 2020 Programme (H2020/2014-2020) under grant agreement nr. 958208. This work was supported by the ValorWaste project "Valorization and integration of mining waste to increase the sustainability of the raw material industry," funded by the Estonian Research Council from the European Regional Development Fund's Mobilitas 3.0 (MOB3ERA4) programme through the ERA-MIN3 network.

ORAL 2

A Denim Dream: Making Use of the Seemingly Useless

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Textile waste continues to accumulate globally, while practical alternatives to non renewable, fossil based packaging plastics remain limited. Effective valorization of post consumer textiles is hindered by the high costs and complexity of selectively processing mixed waste streams. In this work, a route is presented for extracting and modifying cellulose from post consumer cotton textiles and converting it into lightweight foams suitable for packaging applications. Cellulose dissolution and in situ modification with fatty acid chlorides were carried out in a one pot process using an ionic liquid medium, enabling simultaneous derivatization and structuring. The resulting foams exhibited densities as low as $0.17 \text{ g}\cdot\text{cm}^{-3}$, hardness values of 60–93 Shore E, and compressive strengths of 0.29–0.57 MPa, comparable to expanded polystyrene (0.07–0.41 MPa). These results highlight cellulose based foams produced via ionic liquids as promising, more sustainable alternatives to conventional synthetic polymer foams in packaging.

ORAL 3

Wood Treatment Wastewater: A Potential Source of Bio-based Acetic Acid for De-icers from Oil Shale Ash

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Acetic acid is a key chemical for food, pharmaceutical, and industrial applications, with a global market value of about \$19 billion in 2024 [1]. Currently, 90% is produced from fossil sources, while only 10% comes from bio-based routes. As acetic acid accounts for roughly 70% of the cost of calcium and magnesium acetates, identifying a sustainable and low-cost alternative source is essential. In this work, we propose using wood thermal treatment wastewater as a renewable feedstock, enabling the valorization of Estonia's oil shale ash in combination with wood-derived waste streams to produce biodegradable de-icing agents. Previous work has shown that mechanochemistry is an efficient method for producing calcium and magnesium acetates from oil shale ash and glacial acetic acid [2]. To reduce costs and improve sustainability, an alternative source of acetic acid is needed. Wood thermal treatment wastewater is a promising option, containing 8–15% acetic acid depending on the wood type, along with furfural, phenols, and other degradation products. Oxidative treatments such as Fenton and wet air oxidation (WAO) can further increase acetic acid concentration, as it is a degradation product of many volatile organic compounds present in the wastewater. Preliminary Fenton experiments resulted in a ~2% increase in acetic acid and the formation of a clear organic phase, indicating oxidation of furfural and lignin-derived compounds. Initial WAO experiments were conducted under conditions similar to those reported for bio-based acetic acid production from high-furfural wastewaters (270 °C, 20 bar synthetic air, 180 min) [3]. Under these conditions, acetic acid relative concentration based on GC–MS analysis increased from 48% to 88% which shows this method is effective for oxidation of volatile compounds present in the wastewater. WAO represents a promising alternative to Fenton oxidation, as it avoids the generation of secondary waste such as iron sludge. These results indicate strong potential for using oxidative processes to valorize wood thermal treatment wastewater as a renewable source of bio-based acetic acid, enabling the production of eco-friendly deicers in combination with oil shale ash.

References

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3. He, S., Bijl, A., Barana, P. K., Lefferts, L., Kersten, S. R. A., & Brem, G. (2020). Recycling strategy for bioaqueous phase via catalytic wet air oxidation to biobased acetic acid solution. *ACS Sustainable Chemistry & Engineering*, 8(39), 14694–14699. <https://doi.org/10.1021/acssuschemeng.0c05946>

ORAL 4

Methylation of Estonian kukersite kerogen – a step toward kerogen valorization

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Estonian oil shale, kukersite, is a sedimentary rock found in the Baltic Oil Shale Basin containing about 30–50% of organic matter in the form of kerogen. Historically, it has primarily been used for energy and oil production. However, these traditional applications no longer meet modern environmental and sustainability standards. As a result, measures are being taken to limit and eventually stop its use as an energy source. Instead, kukersite kerogen could serve as an abundant source of organic matter. Yet methods for its valorization into chemicals and materials are largely underdeveloped [1]. One possible reason for this is the lack of agreement among existing structural models regarding the content of free hydroxyl groups present in a kerogen structural unit, despite their crucial role in its reactivity. In principle, this information could be obtained through chemical derivatization of kukersite kerogen. To test the feasibility of this approach and estimate the amount of free hydroxyl groups, we undertook the alkylation of kukersite kerogen. In this study, a kukersite kerogen concentrate was methylated with dimethyl carbonate, an environmentally benign methylating agent. The resulting material was analyzed with Fourier-transform infrared spectroscopy, ¹³C cross-polarization/magic angle spinning nuclear magnetic resonance spectroscopy, and elemental analysis. The results suggest that the reaction proceeded almost quantitatively, with no evidence of side reactions. To the best of our knowledge, this is the first successful attempt at O-alkylation of kerogen. Furthermore, based on reaction mass balance and the Lille-Blokker model, it was estimated that an average of 19 methyl groups were introduced per kerogen structural unit, indicating that free hydroxyl groups account for roughly half of the oxygen atoms present in a kerogen “molecule”. This selective methylation reaction sets the stage for further research into kerogen derivatization as a crucial step in its valorization efforts [2].

References

- [1] M. Lopp and K. Kaldas, “Possibilities of the direct chemical transformation of kukersite kerogen: a critical review,” *ACS Omega*, vol. 10, no. 36, pp. 40740–40749, Sep. 2025, doi: 10.1021/acsomega.5c04675.
- [2] K. Rõuk et al., “Methylation of kukersite kerogen – estimation of the content of free hydroxyl groups,” To appear in *Oil Shale*, 2026.

ORAL 5

Textile waste as structural packaging material

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Global fibre production reached 124 million tonnes in 2023, yet less than 1% of textile waste is recycled back into new fibres. Mechanical recycling, the most widely used route, shortens fibres during shredding and ginning, leaving them unsuitable for textile-to-textile closed-loop recycling. The resulting heterogeneous mixtures are typically downcycled into low-value products such as insulation or industrial wipes. Meanwhile, e-commerce packaging, dominated by single-use corrugated cardboard, faces increasing regulatory pressure under the EU Packaging and Packaging Waste Regulation (PPWR) to shift towards reusable, recycled-content alternatives. This study explores whether mechanically recycled textile waste can be converted into rigid nonwoven sheets that meet the structural and durability requirements of e-commerce packaging, addressing both waste valorisation and the need for sustainable packaging alternatives. Various nonwoven prototypes were produced by carding and thermal consolidation using mixed textile waste feedstocks (polyester-cotton blends) and two thermoplastic binder systems - bi-component recycled PET (rPET) and recycled polypropylene (rPP). A commercial E-flute corrugated cardboard served as the benchmark. Nonwoven prototypes were characterised through tensile testing (ISO 527-4) and scanning electron microscopy (SEM). Packaging-level performance was validated using the ISTA 6-Amazon SIOC-A (ISTA 6A) distribution testing protocol. PET-bonded materials achieved stiffness values up to 1220 MPa and stress exceeding 20 MPa at 2% strain - far above corrugated cardboard. rPP-bonded materials showed lower stiffness (250 - 350 MPa) but higher strain tolerance, offering greater energy dissipation under dynamic loading. SEM analysis revealed that mechanical performance is governed by binder chemistry, interfacial bonding efficiency, and thermal consolidation quality rather than binder content alone. Notably, corrugated cardboard failed abruptly at ~4% strain, while textile-based materials sustained progressive deformation throughout the full test range. ISTA 6A distribution simulation further confirmed functional equivalence between both packaging systems. However, cardboard exhibited localised corner degradation post-test, while the textile-based packaging maintained full structural integrity, which is a key advantage for reuse applications under the PPWR. These results show that thermally consolidated textile waste can be converted into structurally reliable packaging material using established nonwoven technologies. Both rPET- and rPP-bonded materials outperformed corrugated cardboard - rPET-bonded sheets with significantly higher stiffness and stress capacity, and rPP-bonded sheets with greater strain tolerance and energy dissipation. These findings highlight the strong potential of textile waste-based nonwovens as durable alternatives to single-use corrugated cardboard.

ORAL 6

Pulsed corona discharge solving micropollutants problem and preserving nutrients in urine-derived fertilizer

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Human urine is a sustainable nutrient source (NPK), but its use as fertilizer is hindered by pharmaceutical residues and nitrogen loss through rapid enzymatic hydrolysis. Degradation of these residues and enzyme deactivation are challenging due to the chemical complexity of urine, where organic molecules compete with reactive species. This research evaluates an energy-efficient technology to simultaneously eliminate micropollutants and arrest urea hydrolysis while preserving nutrient integrity. While advanced oxidation processes (AOPs) like conventional ozonation can oxidize micropollutants, they are often energy-intensive in urine due to radical scavenging by ammonia and organics [1]. This study tests the hypothesis that gas-phase pulsed corona discharge (PCD) can selectively oxidize propranolol (PR) and tetracycline (TC) and irreversibly deactivate the urease enzyme without creating phytotoxic products. Experiments used a 10-L recirculating PCD reactor (123 W pulsed power, 880 pps) with energy doses up to 24.6 kWh/m³. Nitrogen stability was evaluated via real-time electric conductivity (EC) monitoring of urea hydrolysis. Agronomic safety was assessed using *Pisum sativum* growth assays with nitrogen doses from 0 to 100 kg N/ha for treated and untreated urine [2]. Results showed PCD was nearly eight times more energy-efficient for PR removal (90% at 12.3 kWh/m³) than ozonation benchmarks (119 kWh/m³) [3]. The energy efficiency of TC oxidation was 38.9 g/kWh at 90% removal; for comparison, γ -radiolysis achieves near-complete TC degradation at an estimated 32 g/kWh [4]. Real-time EC monitoring confirmed irreversible urease deactivation at 12–13 kWh/m³, preventing ammonia volatilization. Phytotoxicity assays confirmed PCD did not impair fertilizer value: a 25 kg N/ha dose stimulated shoot growth by 38% compared to the reference, with no significant difference between treated and untreated urine. Growth inhibition occurred only at supra-agronomic doses (100 kg N/ha) due to nutrient saturation and acidification rather than PCD-induced toxicity. This study validates PCD as an energy-saving, safe method for valorizing human urine into stable, pharmaceutical-free fertilizer. These findings offer a viable pathway for decentralized nutrient recovery, bridging the energy gap with the Haber-Bosch process by factoring in environmental credits for pharmaceutical elimination and nitrogen preservation.

References

- [1] Dodd et al., *Environ. Sci. Technol.* 2008, 42, 9329–9337.
- [2] ASTM E1963-22, *Guide for Conducting Terrestrial Plant Toxicity Tests*, 2022.
- [3] Dodd et al., *ibid.*
- [4] Jeong et al., *Chemosphere* 2010, 78, 533–540.

ORAL 7

Bridging Polar and Non Polar Worlds: Creating durable Cellulose-PDMS Hybrids via Si–C Linkage

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The increasing push to reuse post consumer cellulose based waste and replace fluorinated water repellent coatings has intensified demand for sustainable, hydrophobic textile materials. Combining cellulose with polydimethylsiloxane (PDMS) offers a promising fluorine free route, but their chemical incompatibility limits their interface stability. Conventional Si-O-C linkages formed through alkoxy silane coupling hydrolyzes fast, compromising durability under humid conditions. In this work, a cellulose-PDMS hybrid was developed using a covalent linkage strategy that replaces the Si-O-C bonds with more stable Si-C based bonds. Hydride terminated PDMS (H PDMS) was modified with allyl glycidyl ether (AGE) via hydrosilylation to create epoxide terminated PDMS. The terminal epoxide was subsequently reacted with cellulose hydroxyl groups under basic conditions to form ether linked cellulose-PDMS materials. This method provides a chemically stronger interface that preserves PDMS flexibility while improving hydrophobicity and moisture resistance. Structural confirmation was obtained using diffusion edited ¹H NMR, and 2D HSQC, HSQC-TOCSY, and HMBC NMR spectroscopy. The approach demonstrates a path toward fluorine free, upcycled cellulose-silicone materials suitable for functional textiles and cellulose films.

ORAL 8

Fast Reaction Yield Monitoring by CE Analysis of Dicarboxylic Acids in Kerogen Valorization Process

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Capillary electrophoresis (CE) is an analytical method, which is widely used for the separation of anionic species in various processes, particularly in industries. The analysis of kerogen, an organic fraction from the Estonian oil shale kukersite, is one such process. Kukersite has been mostly used for oil and electricity production, but it can also serve as a raw material for other industrial fields, such as plasticizer and adhesive production. [1], [2], [3]. In this work kerogen was oxidized into different chain-length (4 to 10 carbons) dicarboxylic acids (DCA) and organic acids with nitric acid. A continuous flow reactor equipped with a built-in sampling option was used for the oxidation of kukersite while CE was employed to analyze the effectiveness of the process. The goal of this work was to improve an old CE method to ensure complete separation of all analytes. [4] Various buffer compositions and electrophoretic parameters were modified to assess their effects on the separation. In the end, the optimal background electrolyte for the analysis of DCA-s was determined to be 15mM maleic acid as the UV absorbing agent, 0.0075% cetyltrimethylammonium bromide (CTAB) as the capillary wall modifier at pH of 12.12, and 11% isopropanol as organic additive. The analytes were detected at 380nm (reference 210nm), and the analysis was carried out using fused-silica capillary with a 50 µm internal diameter that had a total length of 70cm (effective length 61.5cm). Samples were injected hydrodynamically by applying 30mbar for 10 seconds and the separations were performed at 25°C at a voltage of -25kV. Sample preparation was minimal and consisted only of neutralization to ensure that all the DCA's were solubilized. The results described in this work present an optimized CE method that allows the separation of the analytes in kerogen oxidation samples within 8 minutes. Validation confirmed that these improvements enhance efficiency without compromising stability, accuracy, or precision. These findings are broadly applicable to samples containing not only dicarboxylic acids but other analytes that dissociate into anions in an aqueous solution.

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ORAL 9

Formation of Porphyrin Adlayer on Glassy Carbon Electrode Surface from Ionic Liquid Media

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Formation of functional organic adlayers at electrified interfaces is a key step in the design of molecular assemblies, sensors, and energy-storage devices. While porphyrin adsorption has been studied in aqueous and organic electrolytes, its kinetics and impact on electric double layer (EDL) formation in highly viscous ionic liquid (IL) systems remain poorly understood[1]. In such systems, slow mass transport and long equilibration times introduce additional complexity, making time a decisive experimental parameter[2]. Therefore, fundamental knowledge is required to understand the kinetics of adlayer formation. The main factors that determine the formation of an organic adlayer are: adsorbate-adsorbate and adsorbate-substrate interaction energy, as well as surface diffusion and adsorption[3]. In this work, the formation of a porphyrin adlayer at a glassy carbon electrode from IL media was investigated using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). The electrolyte consisted of 1-ethyl-3-methylimidazolium tetrafluoroborate (EMImBF₄) containing 5,10,15,20-tetra(4-pyridyl)porphyrin (TPyP) at concentrations of 0.01 wt% and 0.05 wt%. The influence of porphyrin concentration and equilibration time on EDL formation and interfacial kinetics was analysed. At low porphyrin concentration (0.01 wt%), CV measurements revealed a transient increase in cathodic current density ($-j$) near -0.9 V during the early stages of equilibration. Scan-rate analysis demonstrated diffusion-controlled kinetics, indicating that this feature arises from the initial reorganisation of EMIm⁺ cations within the EDL before significant porphyrin adsorption occurs. With increasing equilibration time, this feature disappears as TPyP molecules reach the interface and progressively replace EMIm⁺, leading to the formation of a TPyP-covered surface. At higher porphyrin concentration (0.05 wt%), this transient behaviour is absent, indicating more rapid surface coverage from the beginning of the experiment. EIS analysis shows that TPyP markedly accelerates interfacial stabilisation: while neat EMImBF₄ requires up to 14 days to reach a stationary EDL state, TPyP-containing systems stabilise within only a few days[2]. After equilibration, the series capacitance curves overlap at both concentrations, demonstrating that the electrode surface becomes covered with porphyrin molecules regardless of the initial TPyP content. Results demonstrate that porphyrins act as strongly adsorbing, surface-active additives that control both the kinetics and final structure of the EDL in the selected IL system. The study highlights the critical roles of equilibration time and additive concentration when interpreting electrochemical data in IL-based hybrid organic–ionic systems.

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ORAL 10

A quantitative approach to determine water and moisture content of different types of lignin using attenuated total reflectance Fourier transform infrared spectroscopy combined with partial least squares regression

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Moisture content significantly influences the chemical and physical properties of natural materials, affecting the stability, mechanical performance, and biodegradability of biopolymers. Accurate determination of water and moisture content in lignin is therefore essential for understanding its physicochemical behaviour, processing characteristics, and application potential in bio-based materials. Conventional techniques such as Karl Fischer titration, oven drying, and freeze drying are reliable but often time-consuming and method-specific. In this study, a rapid, non-destructive, and unified analytical approach based on attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy combined with partial least squares regression (PLS-R) was developed to predict water and moisture content in lignin. A diverse set of lignin samples with varying moisture levels was used to construct and validate chemometric models corresponding to multiple reference methods. The developed models demonstrated strong predictive performance and robustness across different lignin types and moisture ranges. Key spectral regions associated with O–H stretching and H–O–H bending vibrations were identified as major contributors to model accuracy. The models achieved root mean square error of cross-validation (RMSECV) values ranging from 0.53% to 0.66%, and root mean square errors of prediction (RMSEP) of 0.63% for vap-C-KFT, 0.70% for freeze drying, 0.33% for oven drying (48 h), and 1.0% for oven drying (7 h). These results demonstrate that ATR-FTIR combined with PLS-R provides a rapid, non-destructive, and cost-effective alternative for routine moisture analysis in lignin, with strong potential for broader application in lignocellulosic biomass and other biopolymeric materials.

ORAL 11

Unified pH_{abs} scale in 1,2-dichloroethane and 1,2-difluorobenzene

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In water, pH is defined as the negative logarithm of the activity of hydrogen (H^+) ions in solution and pH measurement is well established. In contrast, measuring pH in organic solvents or solvent mixtures is challenging because H^+ ion solvation differs between media, leading to solvent-specific pH scales. The unified pH (pH_{abs}) scale was introduced to connect the pH scales in different solvents thermodynamically using the absolute standard chemical potential of the H^+ ion in the gas phase as a common reference. In practice, the $\text{pH}_{\text{abs}}^{\text{H}_2\text{O}}$ values – pH_{abs} aligned with and directly comparable to the aqueous pH scale – are mostly used. pH_{abs} scale has been established for aqueous–organic mixtures of ethanol, methanol, and acetonitrile, but not yet in low-polarity solvents. 1,2-DCE and 1,2-DFB are inert low-polarity low-basicity solvents but still have sufficient polarity and solvating ability to dissolve many polar and ionic compounds at measurable concentrations, making them suitable for studying acids and superacids. In this work, we establish the unified pH_{abs} scale in these solvents. Relative acidities were measured using differential potentiometry, yielding $\Delta\text{pH}_{\text{abs}}$ values between solutions. Measurements were performed using a symmetric potentiometric cell with two metal solid-contact glass electrodes and an ionic liquid, triethylammonium bis(trifluoromethylsulfonyl)imide $[\text{N}_{2225}][\text{NTf}_2]$, as salt bridge electrolyte. The $\Delta\text{pH}_{\text{abs}}$ values were used to construct the pH_{abs} ladder in each solvent and to assign $\text{pH}_{\text{abs}}^{\text{H}_2\text{O}}$ values for 19 acid solutions in 1,2-DCE and 22 acid solutions in 1,2-DFB via least squares minimization. The scales were anchored to aqueous standard pH buffer solutions, enabling direct comparison to the conventional aqueous pH scale. The resulting pH_{abs} scales span more than 10 orders of magnitude, ranging from -2.9 to 11.0 in 1,2-DCE and -0.6 to 10.0 in 1,2-DFB. The pH_{abs} scales had consistency standard deviations of 0.17 and 0.30 pH units, respectively. These values are higher than those in aqueous-organic media, indicating the challenge of potentiometric measurements in low-polarity solvents. The potentiometric $\text{pH}_{\text{abs}}^{\text{H}_2\text{O}}$ values were compared with those derived from pK_a values obtained by UV-Vis spectrophotometric titration and show good agreement. These results demonstrate that potentiometric $\text{pH}_{\text{abs}}^{\text{H}_2\text{O}}$ measurement is feasible in low-polarity solvents and enables experimental integration of more solvents into the unified pH_{abs} scale.

ORAL 12

Design and structural stability of hybrid mRNA-DNA origami nanostructures

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DNA origami enables the programmable construction of nucleic acid nanostructures with precise geometry and functionality, and recent advances have extended this concept to hybrid mRNA-DNA origami systems capable of controlled protein translation and virus capsid mediated delivery. However, the structural design principles governing the stability and integrity of mRNA scaffolded origami nanostructures under biologically relevant conditions remain poorly understood. In this work, we investigate hybrid mRNA-DNA origami nanostructures to with different sequence composition and geometry. Particular focus is placed on how these structural parameters influence the integrity and unpacking behaviour of mRNA-based origami constructs in cellular environments. Additionally, molecular coatings such as viral capsids, lipids, and polymers are explored to evaluate their effects on structural protection, stability, and controlled disassembly. Understanding these structure stability relationships will provide important design principles for developing robust nucleic acid nanostructures for future biomedical applications.

ORAL 13

Discovery of CapRel fused TA antiphage defence system from P1gmypossum P1-like plasmid-phage

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Type II Toxin-antitoxin (TA) systems are bicistronic two-gene operons, in which the toxin gene encodes a toxic protein that induces cell growth arrest, while the antitoxin gene encodes an antitoxin protein that binds to the toxin and neutralizes its effect. They are implicated in biological functions such as plasmid maintenance, stress response, and phage defence (LeRoux & Laub, 2022). As phage defence elements, they provide immunity against bacterial viruses (bacteriophages) by sensing phage infection and inhibiting vital cellular processes to abort phage proliferation. Phages exhibit two distinct life cycles: the lytic and lysogenic cycles. Lytic phages are virulent. They take over the host's machinery to produce mature virions and ultimately lyse the host cells. While the lysogenic or temperate phages integrate their genetic material into the host's genome and live as a prophage, which is replicated along with the host chromosome during cell division. Prophages can be found as phage plasmids (PP) (Wang et al, 2022). They provide benefits to their hosts by offering auxiliary metabolic genes (AMGs) (Holt et al, 2017; Reyes et al, 2010; Shaffer et al, 2020), antibiotic resistance genes (ARGs) (Wang et al., 2022), and immunity systems (Brenes & Laub, 2025; Zhang et al, 2022). P1-like PP have been implicated in the dissemination of the β -lactamase antibiotic resistance gene among diverse bacterial species (Wang et al., 2022). In addition to antibiotic resistance determinants, these PPs often carry immunity systems that protect the host bacteria from invading phages. Notably, these immunity systems are frequently located within a genomic region flanked by *mat* (particle maturation gene) and *lxc* (modulator of C1 master repressor) genes, a region recognized as a diversity hotspot. In P1-like PP M114, Lai & Cooper (2024) identified a single phage gene within this locus; however, its function was not characterized (Lai & Cooper, 2024). Our lab previously characterized an antiphage TA system, CapRelSJ46, encoded in a P1-like phage-plasmid (PP) SJ46. We have established that the system recognizes the capsid protein (gp57) of the Escherichia coli-infecting phage T-even SECΦ27, which inhibits translation via tRNA pyrophosphorylation (Zhang et al., 2022). Here, we functionally characterize the previously unannotated gene from P1-like PP M114, hereafter referred to as CapRelM114, a homolog of CapRelSJ46, and investigate its role in phage defence.

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ORAL 14

The Formation Of Adaxial Stomata And Their Role In Plant Stress Response And Growth

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Stomata are microscopic pores through which plant leaves control water loss and gas exchange, while also allowing entry of plant pathogens and air pollutants. Thus, its regulation is critical for plant productivity and stress management. Although many plants have stomata only in the lower (abaxial) leaf surface, some such as the model plant *Arabidopsis thaliana* also develop stomata in the upper (adaxial) leaf surface. Not much is known on how adaxial stomata are formed and what role they play in plant gas-exchange, growth, yield and disease resistance. The aim of the project is to understand, how adaxial stomata are formed in *Arabidopsis* and how the ratio of adaxial and abaxial stomatal densities affects plant productivity and stress resistance. During the project, plant lines with altered adaxial stomatal densities will be isolated, the role of the phytohormone abscisic acid which is a key regulator in stomata closure and of stomatal ratio regulation will be addressed and growth traits will be characterised under normal and deficit conditions in plant lines with modified stomatal ratios. The project will result in an improved understanding of the formation of adaxial stomata, their role in plant physiology, gas-exchange, growth, yield and disease resistance, thus generating knowledge that can be applied in breeding for improved yields which is critical for global food security under current climate change conditions.

ORAL 15

Roles of small GTPases in the regulation of plant gas exchange

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Understanding the mechanisms of plant adaptation to environmental cues is of high importance as ongoing climate change threatens food security. Plants respond to changes in their environment by regulating stomatal conductance through a complex network of signaling pathways in guard cells. This in turn controls plant key growth parameters, uptake of atmospheric CO₂ for photosynthesis and transpiration of water. In a large-scale forward genetic screen employing ozone (O₃) sensitivity in *Arabidopsis thaliana*, we identified a mutant with a substitution in the small GTPase ROP6. Shapes of pavement cells in this line indicated that the novel mutation in ROP6 results in plant phenotypes similar to those in the previously identified dominant negative *rop6* mutants. We compared our *rop6* mutant with other lines carrying mutations in ROP6 and ROP2, a functional antagonist of ROP6. In our study, we used a custom-made gas exchange measurement system for detecting rapid changes in stomatal conductance. We found that dominant negative mutations in ROP6 lead to increased steady-state stomatal conductance and inhibit stomatal responses to high CO₂, O₃ pulse, and an application of abscisic acid spray. Constitutively active mutation in ROP2 also leads to inhibition of stomatal responses, as has been shown in previous studies. Our results suggest that functional ROP6 is crucial for controlling stomatal apertures in response to environmental cues, acting antagonistically to ROP2.

ORAL 16

Flow-Opt: Scalable Centralized Multi-Robot Trajectory Optimization with Flow Matching and Differentiable Optimization

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Planning safe and efficient paths for many robots at once can produce better overall movement, especially in crowded or narrow spaces. However, solving this problem exactly becomes too slow as the number of robots grows. We introduce Flow-Opt, a fast learning-based method that closely approximates high-quality joint planning for many robots. Our approach works in two stages. First, a learned generative model quickly proposes possible robot trajectories. Then, a learned safety module refines these proposals so they satisfy constraints such as avoiding collisions. The generative model is based on a modern sequence model that also uses information about the robots' states and the environment map. The safety module includes a custom optimization solver with a neural network that predicts good starting points, making the refinement step much faster. This prediction network is trained automatically using feedback from the solver itself. We show that Flow-Opt can plan trajectories for dozens of robots in cluttered environments in just a few tens of milliseconds, making it several times faster than existing centralized optimization methods. It also produces smoother trajectories and is far faster than competing diffusion-based approaches. In addition, all parts of the method can run in parallel, allowing many planning problems to be solved together in a fraction of a second. Finally, Flow-Opt can generate multiple distinct solutions for the same start and goal setup, capturing different ways robots may coordinate to avoid one another.

ORAL 17

Multi-Objective Policy Design using Reinforcement Learning in 6G Networks

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Sustainable 6G wireless networks are expected to deliver jointly optimized key performance indicators (KPIs) to meet growing demands for highly reliable, energy-efficient, and massively connected devices. Balancing these inherently conflicting objectives under stringent energy, latency, and computational constraints remains challenging. Multi-Objective Reinforcement Learning (MORL) enables the study of Pareto efficient trade-offs; contemporary wireless solutions generally rely on static scalarization or multiple trained policies, and rarely accommodate rapid, context-sensitive preference adaptation. We propose Wireless Multi-Objective Conditional Envelope PPO (WiMO-CEPPO), a centralized single-agent MORL framework that learns a single preference-conditioned policy and adapts online to varying network conditions without retraining. WiMO-CEPPO integrates: (i) a context-to-preference mapper that infers objective priorities from real-time network state, (ii) a conditional envelope mechanism that attenuates policy updates under strong inter-objective conflict, and (iii) a sustainable reward formulation that jointly accounts for energy efficiency, connectivity, reliability, interference, and hardware sustainability. Simulation results illustrate that WiMO-CEPPO outperforms representative MORL baseline methods in Pareto trade-off quality and key wireless KPIs, while improving training stability under conflicting objectives.

ORAL 18

Flow-Guided Trajectory Refinement for Safe Navigation on Uneven Terrain

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We propose a trajectory refinement framework for safe mobile robot navigation over uneven terrain, where classical global planners often produce paths that lead to instability, excessive roll, or traversal through hazardous regions such as ditches. Given an initial global path, our method combines a conditional flow matching model with Cross-Entropy Method (CEM) optimization to generate terrain-aware and dynamically feasible trajectories. The flow model learns a continuous velocity field that transforms trajectory samples toward regions consistent with expert demonstrations while conditioning on rich terrain representations such as elevation maps, surface normals, and uncertainty estimates. In parallel, CEM iteratively samples and refines candidate trajectories, enforcing safety and optimality by penalizing unstable configurations and high-risk terrain features. This hybrid approach enables adaptive correction of global paths, producing smooth, feasible trajectories that avoid dangerous terrain and improve traversal safety. Experimental results demonstrate a reduction in failure cases, including rollovers and unsafe terrain interactions, compared to baseline planners, while maintaining computational efficiency suitable for real-time deployment.

ORAL 19

Guidance and control of fixed wing aerial vehicles

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Autonomous Fixed-Wing Aerial Vehicles (FWVs) are widely used for exploration and mapping of large outdoor terrains. Increasing commercial availability leads to the rise in the application range, for example, surveillance in obstacle-rich urban environments. However, existing guidance strategies for FWVs are reactive or computationally too demanding for deployment on embedded hardware. Additionally, conventional robotics approaches often treat hardware and software design independently, which is suboptimal for FWVs where hardware design directly affects aerodynamics, stability and maneuverability. Our research focuses on the development of guidance and control algorithms for FWVs that consider control theory, computational constraints and hardware design. The key hypothesis is that real-world flight data can improve the efficiency and accuracy of guidance strategies, while hardware–software co-design could benefit overall system performance. Our study combines simulation, software-in-the-loop simulations and real life experiments. Current work builds on Model Predictive Path Integral (MPPI) control, a sampling-based method for optimal trajectory planning. While effective, MPPI is computationally heavy and tends to produce non-smooth control signals. To address these challenges, a projection-based variant π -MPPI was developed to enforce smoothness and feasibility of control inputs. Also, learning-based warm-start strategy is proposed for the underlying projection filter to aid the convergence and reduction in computational speed. The results have shown that π -MPPI produces smoother controls without sacrificing the success rate in comparison to the baseline MPPI variant. This approach could be especially valuable in the scenarios where the need high fidelity guidance and control algorithms is required for safe operation of the FWV. Ongoing work focuses on learning warm-start policies directly for MPPI, with the aim of reducing the number of required samples and improving sample quality, thereby further enhancing real-time performance. In addition, a custom FWV hardware platform was developed to facilitate real-world testing of the proposed algorithm. Real flight data, including pilot demonstrations, will be used to improve the agreement between predicted and actual system dynamics, enabling more accurate modeling under applied control inputs.

ORAL 20

Cyber-Physical Security of DC Microgrids

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This research presents a cyber-physical testbed for analyzing the impact of communication-layer cyber attacks on Direct Current Microgrid (DC-MG) operation. A switching-level DC-MG is implemented in Typhoon VHIL and integrated with a secure Message Queuing Telemetry Transport (MQTT) protocol-based communication architecture. Operational measurements are published from a real-time simulator to a Mosquitto broker hosted by a Raspberry Pi module, while selected control references are received to enable closed-loop operation. An ESP32 IoT device, a Python-based data logger, and a Power BI dashboard provide monitoring, logging, and visualization, respectively. Normal and cyber-disturbed datasets are logged over 24 h at 1 s resolution initially, incorporating five controlled cyber-physical attack scenarios to quantify how cyber disturbances propagate from the communication layer to physical system behavior. Results demonstrate that cyber disturbances primarily impair monitoring accuracy, control responsiveness, and system observability, emphasizing the need for impact-aware security assessment in DC microgrids.

ORAL 21

Comparative assessment of heat source integration for large-scale heat pumps in district heating systems

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Large-scale heat pumps (LSHPs) are increasingly recognized as a key technology for decarbonizing district heating systems; however, their performance strongly depends on the characteristics of the heat source. This study presents a comparative assessment of LSHP integration using multiple heat sources, including ambient air, wastewater, and industrial excess heat, within a unified modelling framework. Thermodynamic and economic model is developed to evaluate system performance under varying source temperatures, supply temperature levels, and electricity price conditions. The analysis highlights how source temperature stability and availability influence coefficient of performance (COP), operational costs, and overall system efficiency. Results indicate that wastewater and industrial waste heat offer superior and more stable performance due to higher and less variable temperatures, while air-source systems exhibit greater sensitivity to climatic conditions. Furthermore, the study demonstrates the critical role of low-temperature district heating networks in enhancing LSHP efficiency across all source types. By quantifying trade-offs between different heat sources, this work provides practical guidance for selecting optimal LSHP configurations in early-stage planning. The findings contribute to a better understanding of source-dependent performance and support the strategic deployment of heat pumps in future sustainable heating systems.

ORAL 22

Nanoscale multi-physics simulations of vacuum arc initiation

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Vacuum arc development has been previously studied by simulations focusing on different aspects of plasma initiation, surface modification, heating and emission. We describe the development of a model that concurrently couples particle-in-cell (PIC) plasma simulation and molecular dynamics (MD) to study how these phenomena are linked in vacuum arcing. Surface morphology changes influence emission and heating characteristics of metal surfaces under high electric field, which in turn leads to differences in plasma development. Bombardment of ions from this plasma can result in modification of the surface by processes such as sputtering. This coupling is achieved by a particle exchange process between the PIC and MD systems. We simulate the development of the initial plasma around a Cu nanotip and the resulting surface effects using the FEMOCS code. Separation, heating and evaporation of Cu nanoparticles is modelled with electron beam interactions. These developments focus on the initial stages of vacuum arcing, aiming to better understand the process on a fundamental level.

ORAL 23

Edge-Deployed Intelligence and Multimodal Interaction for Robotic Study Companions

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Deploying social robots as educational companions in the wild demands two things: cultural adaptability and data privacy. The Robot Study Companion (RSC; rsc.ee) project is an open-source, multimodal social robot designed to support university students [1]. Here we report on two frontiers: cross-cultural user acceptance and localised machine intelligence. Initial studies show participants perceived the RSC positively, rating it highly for its potential to enhance self-learning, retention, academic performance, and ease of learning [2]. A further study presents findings from comparative research conducted in Estonia and Guyana, revealing how university students interpret multimodal emotional expressions across various academic scenarios [3]. The results suggest that students have distinct preferences regarding robotic personalities and their effects on engagement. Finally, we benchmark 25 edge-deployed language models across inference speed, energy efficiency, and teaching effectiveness, identifying models suitable for running locally on a Raspberry Pi 4 to ensure that the RSC remains safe and secure [4]. The RSC project synthesises emotive design with hardware-constrained intelligence, offering a blueprint for ethically grounded, culturally aware social robots in diverse global contexts.

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ORAL 24

An augmented reality interface for safer human-robot interaction in manufacturing

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With the adoption of Industry 4.0 and emerging ideas of Industry 5.0, the manufacturing industry is shifting back towards human-centered production. In these scenarios, collaborative robots (cobots) become an important part of this shift towards human-robot collaboration (HRC). However, with the introduction of robots meant to work in close proximity to and in collaboration with people, problems of safety and collaboration efficiency arise. On the other hand, there are developments in the field of Augmented Reality (AR), which enables the visualization of digital information overlaid onto physical objects and having people interact with it. This work proposes an AR interface to collaborate with cobots. The interface consists of 2 parts. The first one is the interactive AR user interface, which allows the user to program robot movement by setting up goals and obstacles. The second one is a physics-based motion planner which plans the movement of real robot based on the goals and obstacles received from the AR interface.

ORAL 25

Dynamic Nested Hierarchies: Self-Evolving Machine Learning Architectures for Lifelong Learning

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Contemporary machine learning models achieve remarkable performance on static tasks but struggle in non-stationary environments due to rigid architectures. This rigidity causes catastrophic forgetting, poor out-of-distribution generalization, and inability to continually acquire new knowledge without retraining. These limitations are critical in real-world applications like autonomous robotics, conversational AI, and medical diagnostics, where environments change continuously and models must adapt throughout their lifetime. The root cause is the fixed parameterization and static update mechanisms of traditional deep networks, which cannot support the multi-timescale adaptations required for lifelong learning. This work proposes Dynamic Nested Hierarchies (DNH), extending the Nested Learning paradigm to enable autonomous structural adaptation. While standard Nested Learning uses fixed hierarchy depth and update frequencies, DNH introduces three biologically grounded mechanisms. Level addition, triggered when meta-loss exceeds a threshold, mirrors adult neurogenesis in the hippocampal dentate gyrus, expanding representational capacity when needed. Level pruning removes redundant levels based on gradient contribution, analogous to synaptic elimination, preventing unbounded growth. Frequency modulation adapts update rates via local surprise signals, analogous to neural oscillation adaptation, enabling faster updates for changing contexts and slower consolidation for stable knowledge. DNH is formalized as a time-varying directed acyclic graph where structure adapts through meta-optimization. Theoretical analysis establishes convergence guarantees under distribution shift, expressivity improvements through dynamic depth, and sublinear regret compared to static architectures' linear regret. Empirical evaluations validate these advantages across language modeling, commonsense reasoning, continual learning benchmarks including Split ImageNet, CLEAR-100, and COrE50, and long-context reasoning up to 128K tokens. DNH consistently outperforms classical methods such as Elastic Weight Consolidation and Synaptic Intelligence, and modern approaches including DER++ and MEMO. Ablation studies confirm each component's contribution, while parameter analysis shows bounded growth of only 8.2 percent over ten tasks with zero inference overhead. This work establishes dynamic hierarchy adaptation as a general architectural paradigm complementary to existing continual learning techniques, provides principled neurobiological grounding beyond superficial analogy, and demonstrates practical viability for real-world lifelong learning systems.

ORAL 26

Beyond the prototype: making open-source robotics last

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Open-source robotics offers clear value for education and research because platforms can be studied, modified, and reproduced. At the same time, sustainability depends on more than just publishing files. Good documentation, editable source files, version control, and support for reuse are all essential for keeping a platform alive. In this research, I focus on why many open-source robot platforms do not survive beyond the first development phase and how they could be developed in a more sustainable way. The working hypothesis is that long-term survival depends less on the robot concept itself and more on documentation quality, maintainability, contributor onboarding, and community support. The study uses comparative qualitative case analysis. Robotont is used as a long-term case, based on more than eight years of active development and maintenance. SemuBot is used as an early-stage case to reflect the challenges and decisions that appear at the beginning of an open-source robotics project. These cases are discussed together with broader open-source platform examples such as Arduino and Prusa, in order to identify practices that support long-term sustainability. The results so far show that survival depends on a few practical factors: clear build and repair instructions, open editable design files, modular design, realistic maintenance planning, and a development model that lowers the barrier for new contributors. The main outcome of the research is a practical framework for developing sustainable open-source robotics platforms. The scientific contribution of the work is not only in the platforms themselves, but in turning development experience and existing open-source principles into reusable guidelines for future robotics projects.

ORAL 27

Development of multifunctional PepFect14 analogs for enhanced mRNA delivery in vitro and vivo

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The success of the mRNA vaccine has opened a new era for mRNA-based therapies and drug delivery technologies (1). However, developing a safe and effective delivery vector remains a major challenge (2). While lipid nanoparticles remain the gold standard for mRNA therapeutics, driven by their notable progress in approved and commercial formulations (3), their limitations have prompted alternative vectors such as CPPs (4). In the current study, we designed multifunctional PepFect14 peptide analogs through structural peptide modification—fatty acid tail and amino acid substitution—to systematically investigate the structure-activity relationship governing PF14-mediated mRNA delivery. The PepFect14 and analogs were synthesized by the solid-phase peptide synthesis technique, and their secondary structure was assessed in water using circular dichroism (CD). Peptide-based mRNA nanoparticles (PBNs) were prepared by bulk mixing (3). Their physicochemical properties were characterized by DLS, and the percent mRNA encapsulated was determined by the SYBR gold standard assay (4). The efficiency of mRNA delivery was evaluated in vitro using cancer cell cultures (HeLa and HEK293T) and in vivo using female Babl/c mice (0.25 mg/kg). The lead peptides—featuring more hydrophobic fatty acid tails (\geq C18), lysine substitution, and a strategic placement of a histidine residue—showed more ordered secondary structure and particle formation with suitable physicochemical properties (< 100 nm, PDI < 0.3 , ZP $> +15$ mV). Furthermore, compared to unmodified PF14, they demonstrated 5- to 10-fold higher protein expression across varying cell lines, with endosomal escape identified as a driver for efficient mRNA delivery. In vivo, systemic IV injection (0.25 mg/kg) in mice of top-performing analogs C22-K[His-K]₂ elicited strong protein expression in the lungs and spleen, providing extrahepatic targeting potential over benchmark LNPs and minimal toxicity. Our rational design of PF14 analogs identifies hydrophobicity as the primary structural determinant. Increasing N-terminal fatty acid tail length (hydrophobicity) drives a more ordered α -helical conformation, pH-responsive membrane disruption, mRNA encapsulation, and robust nanoparticle formation. Additionally, we demonstrated the optimal chain length considerations, charge-structure motif, and histidine content (and placement) that emerge as critical determinants for optimal mRNA delivery. In summary, this construct of a modular technology based on an amphipathic peptide provides a versatile framework that can be fine-tuned to overcome several key constraints currently associated with peptide-mediated mRNA delivery and can be expanded to a broader therapeutic scope.

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ORAL 28

The cellular functions of human HEMK2 methyltransferase

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HemK methyltransferase 2 (HEMK2) is an evolutionary conserved methyltransferase which has been associated with different pathological conditions, such as diabetes, various types of cancers and neurological disorders. While many of these diseases have been attributed to HEMK2's role in regulating gene expression, the exact molecular pathways and cellular processes which HEMK2 is associated with have not yet been fully described. To study the molecular function of HEMK2 in human cells, we established stable U2OS and HCT116 HEMK2-knockout cell lines using the Crispr-Cas9 gene editing system. Our analysis of HEMK2-depleted cells showed a significantly reduced cell proliferation, migration and an upregulation of cell cycle inhibitors p21 and p53. These effects became even more pronounced under serum starvation conditions, where HEMK2 depleted cells ceased to proliferate and showed pronounced changes in both cellular adhesion and morphology. Finally, using untargeted quantitative proteomics followed by functional enrichment analysis we observed a downregulation of proteins related to ribosomal function and translation in HEMK2 depleted cells. This suggests that HEMK2, at least in part, might be involved in various cellular processes through the regulation of protein synthesis. However, further studies are required to determine the mechanisms through which HEMK2 exerts its molecular and cellular functions.

ORAL 29

Towards point-of-care detection of growth factor GDF-15 using an electrochemical sensor

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Growth Differentiation Factor-15 (GDF-15) is a stress-induced cytokine widely studied as a biomarker for metabolic, oncological, and neurodegenerative disorders, with elevated circulating levels reported in conditions such as diabetes, cancer progression, and neurodegeneration [1]. Despite its clinical relevance, recent studies indicate that reliable detection of GDF-15 in complex biological matrices remains challenging due to limitations in the selectivity and sensitivity of existing methods, particularly at low biomarker concentrations in real samples [2]. This work addresses the need for rapid, selective, and cost-effective detection of GDF-15 in clinically relevant environments. We hypothesize that rational epitope imprinting can generate biomimetic receptors with enhanced selectivity, capable of overcoming the limitations of conventional recognition elements. To test this, we developed a redox-active electrochemical sensor based on epitope-selective molecularly imprinted polymer (MIP). A rational epitope selection strategy was employed to identify a peptide fragment representative of the target protein, enabling the formation of selective binding sites within the polymer matrix. The MIP layer was integrated with a redox-active electrode, allowing label-free detection without the need for external reagents. Sensor performance was evaluated across multiple biological matrices, including animal and human serum samples, covering clinically relevant concentration ranges. Electrochemical measurements showed that the sensor exhibits high sensitivity, with a limit of detection of 0.4 pg mL⁻¹, along with excellent selectivity toward GDF-15. Minimal cross-reactivity with non-target proteins confirms the specificity of the imprinted recognition sites. The sensor maintained stable and reliable performance in complex biological environments, supporting its applicability in real sample analysis. These results demonstrate that epitope-imprinted electrochemical sensors enable the detection of GDF-15 in complex biological samples, supporting their use in low-cost and practical diagnostic applications. The presented approach provides a scalable platform for biomarker detection and may contribute to the development of point-of-care technologies.

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ORAL 30

Development of bispecific T-cell engagers against CLDN6 for precision cancer therapy

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Background: Claudin 6 (CLDN6), a tight junction protein, is an oncofetal antigen with limited expression in adult tissues but aberrantly overexpressed in several cancers, including ovarian, testicular, and gastric tumors. Its tumor-specific expression and critical role in maintaining cell adhesion make CLDN6 a compelling target for cancer therapy. Recent studies have linked CLDN6 to tumor progression, metastasis, and chemoresistance, highlighting its potential as both a biomarker and a therapeutic target in precision oncology. This study presents the development of bispecific antibodies for the treatment of CLDN6-positive tumors.

Methods: Monoclonal antibodies specific to CLDN6 were generated using DNA-based immunization boosted with virus-like particles (VLPs) displaying CLDN6 as immunogen. Chickens were selected as immunization hosts to increase the chance of immunogenicity and improve likelihood of obtaining antibody candidates against conserved membrane proteins. Antibody discovery was performed using Icosagen's HybriFree B cell cloning technology and phage display platforms. Monoclonal antibodies from antibody discovery campaign were screened for CLDN6 specificity over other CLDN-family proteins using VLPs and both overexpression and endogenous cell lines. **Results:** Antibodies that specifically recognize CLDN6 were reformatted into different bispecific T cell engager formats carrying a CD3 binding domain. Various bispecific antibody formats were tested and Db-Fc-Fab format emerged as most suitable format in terms of CLDN6-positive cells vs CLDN6-negative cell cytotoxicity. These findings underscore the importance of selecting appropriate bispecific antibody modalities to achieve maximum therapeutic potency while ensuring a favorable safety profile. Furthermore, selected bispecific format shows improved developability profile over parental anti-CLDN6 antibody. The functionality and potency of selected novel bispecific antibody was further demonstrated in vivo using ovarian cancer xenograft model.

Conclusions: This study highlights the development of novel bispecific antibodies targeting CLDN6 and CD3, emphasizing their superior safety profile. The use of specifically engineered antibody modalities and highly selective CLDN6 binders ensures minimal cross-reactivity with other homologous family members. These findings support the potential of these bispecific antibodies as a promising therapeutic approach for CLDN6-positive cancers.

ORAL 31

Legal and Ethical Challenges of CRISPR Gene Editing in Human Therapeutics-biotechnology

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CRISPR-Cas9 has transformed biotechnology, unlocking the potential to cure genetic diseases and revolutionize medicine. While the promise of this gene-editing technology is exciting, its use in humans presents complex legal and ethical challenges that we can't afford to overlook. This thesis dives into the intersection of cutting-edge biotechnology and the laws that are trying to keep up with its rapid advancements. The focus of this research is on the regulatory issues surrounding CRISPR, especially when it comes to developing therapies for human diseases. How do we balance the need for innovation with the responsibility to ensure safety and ethics? I'll explore key legal topics like patenting CRISPR technology, the informed consent process for gene-editing trials, and the liability concerns if things go wrong. Additionally, it tackles the broader ethical questions around germline editing, the idea of creating "designer babies," and the long-term impacts of genetically modifying humans. Ultimately, this work aims to suggest a path forward—one that allows CRISPR to flourish while making sure we're still protecting individuals' rights and public health. It's not just about what CRISPR can do but also about how we as a society can regulate it responsibly. Through this research, I hope to offer a framework for navigating these challenges, ensuring that as biotechnology evolves, the law and ethics evolve with it.

POSTER ABSTRACTS

POSTER 1 – SESSION A

3D printing of geopolymer binder based concrete structures by adapting tabletop clay printers

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This study presents an experimental investigation into the development of an accessible geopolymer concrete (GPC) formulation and a corresponding low-cost 3D printing platform. Although concrete 3D printing is a rapidly advancing manufacturing approach, its broader adoption remains limited due to regulatory constraints and the high entry barrier associated with specialised and expensive equipment. The present work addresses whether a modified, low-cost tabletop clay printer can be effectively adapted for geopolymer-based additive manufacturing, and how formulation and processing parameters influence extrusion behaviour and defect formation. A dedicated mix design was developed to promote geopolymerisation while achieving suitable rheological performance, incorporating sodium carboxymethyl cellulose (Na-CMC) as a viscosity-modifying additive to enable a low water-to-solid ratio without compromising workability. The printer modification procedure and material formulation are described in detail to support reproducibility and comparability. Material performance and print quality were evaluated through extrusion observations, multiscale defect analysis, 7-day direct tensile testing of 3D-printed dog-bone specimens, and ATR-FTIR spectroscopy. The results demonstrate successful extrusion and polymerisation, with the printed material achieving sufficient direct tensile strength. These findings indicate that low-cost hardware can be adapted for geopolymer-based additive manufacturing, contributing to more accessible and lower-carbon alternatives to conventional concrete.

POSTER 2 – SESSION A

Vanillin-Based Polymethacrylate Covalent Adaptable Networks: Synthesis and Characterization

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Thermoset polymers are valued for strength and durability, but their permanent crosslinks make recycling difficult; one approach to improve end-of-life options is to use covalent adaptable networks (CANs) where crosslinks are formed through dynamic covalent chemistry. In this work, lignin-derived vanillin (containing an aldehyde group) was used to introduce crosslinkable functionality into methacrylate- and acrylate-based copolymers. Vanillin methacrylate (VMA) was synthesized via methacrylation of vanillin and purified by recrystallization. The structure of monomer was confirmed by ¹H NMR spectroscopy. Then linear copolymers of VMA:methyl methacrylate (MMA):butyl acrylate (BA) with targeted compositions 5:55:40, 10:50:40, and 25:50:25 were prepared by conventional radical solution polymerization in DMSO (AIBN, 63 °C). Incorporation and composition were determined by ¹H NMR using characteristic signals (VMA aldehyde ~9.95 ppm, MMA methoxy ~3.58 ppm, BA methylene ~3.98 ppm), and size exclusion chromatography (SEC) confirmed that the products were soluble linear polymers prior to crosslinking. Networks were formed by reacting the aldehyde groups with adipic dihydrazide (ADH) at ADH:VMA molar ratio of 1:2, producing CANs with hydrazone-type linkages; after crosslinking, samples became insoluble in chloroform, consistent with network formation. FT IR and DSC were used to compare linear and crosslinked materials; BA-rich compositions showed lower glass transition temperatures (T_g) due to increased chain mobility, while crosslinking increased T_g relative to the corresponding linear precursors. The extent of network formation was quantified by gel content/swelling in THF (24 h) and related to VMA content (functional group density), providing a basis to connect comonomer ratio, thermal behavior, and network formation in vanillin-based polymethacrylate CANs.

POSTER 3 – SESSION A

Nutrient and geographic effects on fungal diversity in sediments

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Pollution and climate change have caused significant damage to aquatic habitats. This includes the aquatic microbiome, which is crucial to the functioning of aquatic ecosystems. Fungi are an integral part of the aquatic microbiome, contributing as decomposers, parasites, pathogens and mutualists. However, aquatic fungi are under-researched in comparison to other aquatic microorganisms and terrestrial fungi. Given their ecological importance, identifying the factors that shape aquatic fungal communities is essential for understanding and protecting aquatic ecosystems. The FunAqua project, launched in 2018 by the University of Tartu and the Estonian University of Life Sciences, aims to characterize global patterns in aquatic fungal biodiversity using metabarcoding data from more than 2,300 sediment and filtered water samples. We present preliminary results of biodiversity analyses conducted on 347 sediment samples collected between 2018 and 2022. These samples represent 41 countries, eight aquatic biomes, and six continents. The study investigates how geographic and chemical variables influence aquatic fungal biodiversity using statistical analyses of metabarcoding community data. Phosphorus, potassium, calcium, magnesium, and iron are essential nutrients for fungal growth. However, excessive concentrations of these ions can disrupt cellular homeostasis. We therefore hypothesize that both low and high concentrations of these nutrients are associated with reduced fungal alpha diversity. Additionally, previous research on terrestrial fungi has demonstrated latitudinal and elevational diversity gradients, thus we hypothesize that a similar effect can be seen in the case of aquatic fungi. DNA was extracted from sediment samples and the ITS region of the rRNA operon was amplified for metabarcoding. Sequencing was performed at the University of Oslo using the PacBio Sequel platform. In total, 6,246 fungal OTUs (296,675 sequences) were detected. Sediment nutrient concentrations were quantified via atomic emission spectrometry. Random forest modelling was used to assess the effects of environmental variables on alpha diversity. The resulting model explained 24% of the variance in fungal alpha diversity. Sampling plot was the strongest predictor, indicating plot specific differences not captured by other variables. All nutrients except phosphorus were shown to be significant predictors of alpha diversity. Both latitude and longitude were significant predictors, whereas elevation showed no detectable effect. Because elevated nutrient concentrations can arise from pollution, our findings suggest that anthropogenic nutrient loading may alter aquatic fungal species richness and thus potentially influence ecosystem functioning.

POSTER 4 – SESSION A

Antibacterial compounds against non-growing bacteria

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Antibiotics are defined by their ability to inhibit bacterial growth. Effect on non-growing bacteria is not sufficiently investigated, even though non-growing or slow-growing bacteria play an important role in chronic and recurrent infections, such as urinary tract infections (UTIs), tuberculosis, or lung infections of cystic fibrosis patients. We asked whether we could find compounds among existing drugs and drug candidates that can kill non-growing bacteria. Our hypothesis was that we would find some antibiotics and potentially other drugs that could kill the non-growing bacteria. For this, we screened 6454 compounds by measuring their effect on non-growing uropathogenic *E. coli* (UPEC). The compounds belong to drug repurposing libraries, including drugs available on the market as well as drug candidates with some associated clinical study data. Out of the 6454 compounds, 38 molecules (~0.6%) from various drug classes were active against non-growing UPEC: hits were mostly antibiotics such as fluoroquinolones and macrolides, but also anti-cancer drugs and disinfectants. Amongst these, the fluoroquinolones sitafloxacin and gatifloxacin had the strongest killing effect. We also found that the effect of several compounds was not limited to UPEC. Clinafloxacin, sitafloxacin, mitomycin C, and solithromycin reduced counts of non-growing *P. aeruginosa* by over 99.99% at concentrations as low as 2.5 μ M, while alexidine hydrochloride and mitomycin C reduced non-growing *S. aureus* by over 99.99% at 10 μ M concentrations. Additionally, we saw that these compounds delayed regrowth within 1-3 hours of treatment and in some cases (e.g solithromycin) were active at very low concentrations where growing bacteria would not be affected. These results highlight the potential of sitafloxacin and gatifloxacin in particular and fluoroquinolones in general as a treatment option for recurrent infections. Combined with robotics and automated colony counting solutions, the throughput of this workflow can be expanded for testing other clinically relevant pathogens.

POSTER 5 – SESSION B

Electrooxidative Iodination of Carbonyl Compounds

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Iodine-containing organic molecules hold significant value in both industrial processes and medicinal chemistry. Moreover, they are useful intermediates and synthons in organic synthesis, particularly in numerous carbon-carbon bond forming and iodine-metal exchange reactions. We describe a direct anodic iodination of carbonyl compounds; protocol enables selective formation of α -iodocarbonyls under mild conditions. This work comprises quaternary ammonium salt as halogen source, which is commercially available, stable, inexpensive, and commonly used for organic reactions. By employing electrons as a potent, controllable, and traceless alternative oxidant, our method eliminates the use of external oxidants, usually employed to oxidise iodide. Thus, it demonstrates excellent tolerance towards oxidant sensitive substrates like aldehydes. Additionally, our batch reaction conditions can be scaled up upon the introduction of continuous flow method.

POSTER 6 – SESSION B

Early-stage development of a MIP-based sensor array for the detection of mycotoxins

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Mycotoxins are secondary metabolites produced by filamentous fungi. They are major contaminants in water bodies and animal feed, posing significant risks to livestock and, indirectly, to human health, including chronic liver and kidney diseases. Different types of mycotoxins coexist in nature, with aflatoxins and ochratoxins being the most common, and detecting them is crucial to minimizing their toxic effects. Conventional detection methods, such as high-performance liquid chromatography (HPLC) and thin-layer chromatography (TLC), are time-consuming and require sophisticated instruments and skilled personnel. Immunoassays, such as enzyme-linked immunosorbent assay (ELISA), depend on costly, unstable antibodies, which can lead to false-positive results. On the other hand, Molecularly Imprinted Polymers (MIPs), also known as synthetic receptors, offer a promising alternative due to their stability, selectivity, and cost-effectiveness. Integrating MIPs with electrochemical transducers offers a powerful approach for developing portable sensors with real-time monitoring capabilities, user-friendliness, low cost, and high sensitivity. A ruthenium oxide (RuO₂) electrode functions both as the transducer and as an intrinsic redox probe, enabling direct monitoring of molecular binding events between the target analyte and the MIP layer directly in a sample solution. The aim of the study is to develop an electrochemical sensor array system based on a RuO₂/MIP combination for the detection of aflatoxin B1 (AFB1) and ochratoxin A (OTA). Initially, the system will be designed for a single mycotoxin, with later development of an array for the detection of multiple toxins. Since mycotoxins are extracted using organic solvents due to their high solubility, it is essential to optimize the solvent composition that is compatible with both the extraction process and subsequent analytical testing. Organic solvents are less conductive and can significantly influence the electrochemical activity of RuO₂, leading to a noticeable drop in signal. As starting points, DMF and ethanol were selected due to their strong solubilizing capacity for mycotoxins. Evaluation of RuO₂ electrode stability in DMF-PBS and Ethanol-PBS solutions demonstrated optimal electrochemical signal recovery at 30% DMF and 50% ethanol, which is useful for the extraction and analysis of real mycotoxin samples. Ongoing work is focused on determining a single solvent system compatible with both mycotoxins. In parallel, a computational approach based on molecular docking is used to select optimal functional monomers for MIP synthesis based on their binding energies.

POSTER 7 – SESSION B

Stomatal regulation of tomato leaves and flower buds under ABA and environmental stress

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Recent studies have shown that stomatal regulation in tomato can be organ-specific under heat and drought stress: leaf transpiration is more strongly limited by water availability, whereas flower transpiration appears to be more temperature-responsive and associated with differences in ABA metabolism (Jensen et al., 2024). However, the role of ABA in stomatal responses to changing evaporative demand remains debated, particularly in reproductive organs, for which data are still limited. This study asks how stomatal responses of tomato leaves and flower buds differ under low relative humidity, elevated temperature and exogenous ABA, and whether stomatal closure is retained in ABA-deficient material. We hypothesize that flower-bud stomata are regulated differently from leaf stomata and that partial closure may still occur in the ABA-deficient mutant *flacca*, indicating regulatory components beyond purely hydropassive responses. The study tests three tomato genotypes, one of which is the ABA-deficient mutant *flacca*, and compares two organs, leaves and flower buds, under three treatment types: low relative humidity, temperature shifts and ABA application. Stomatal conductance and gas exchange are measured with the LI-6800, and ongoing analyses examine the relationship between stomatal behaviour and ABA content across genotypes and organs. Initial measurements indicate that leaf and flower-bud responses are not identical, and preliminary data suggest that stomatal closure under low humidity may also occur in ABA-deficient material, while flower-bud responses cannot yet be explained solely by hydropassive water loss. This work extends current knowledge of stomatal regulation from vegetative to reproductive organs and may help identify physiologically relevant traits for tomato breeding aimed at improved stress tolerance and yield stability under changing climatic conditions.

POSTER 8 – SESSION B

History-Aware Monocular Navigation via Latent Flow Matching and Risk-Aware MPC

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Monocular vision-based navigation in cluttered environments remains challenging due to the absence of direct depth perception. MonoMPC [1] addresses this limitation through a learned probabilistic collision model combined with risk-aware model predictive control (MPC). However, it operates on instantaneous observations, lacking temporal memory that is critical for reasoning about dynamic scenes and handling partial occlusions. In this work, we extend MonoMPC along two key axes. First, we add a history of H past depth point clouds to the collision model to give it more temporal context. These are encoded using PointNet-based feature extractors with positional embeddings and fused via a transformer architecture, enabling the model to capture scene dynamics rather than relying solely on the current frame. The resulting history-aware collision model is integrated into a CEM-based MPC framework for selecting low-risk trajectories. Second, we introduce learned generative control prior to improving trajectory sampling within the MPC framework. Specifically, we model a distribution over feasible 50-step control sequences—jointly parameterizing linear and angular velocities—by compressing them into a 32-dimensional latent space using a 1D convolutional autoencoder. A conditional flow matching (CFM) model is trained to generate diverse, dynamically feasible control trajectories via ODE-based sampling in a single forward pass, conditioned on visual history and robot state. These samples are used to initialize and guide the CEM-based MPC, significantly improving sampling efficiency and trajectory quality without altering the underlying optimization procedure. Real-world experiments conducted on a ground robot in cluttered indoor environments demonstrate that our approach consistently reaches the goal without collision in challenging scenarios that defeat baseline methods. These results highlight temporal scene understanding and learned trajectory priors as critical components for reliable monocular navigation and confirm that our framework is computationally efficient and suitable for real-time deployment on mobile robotic platforms.

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POSTER 9 – SESSION B

Predicting Time Dependent Fragmentation and Stability Limits in Silver Nanowire Networks

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Silver nanowire (Ag NW) networks are key building blocks for flexible and transparent electronics, conductive films, and sensing platforms, but their performance is often limited by heat-induced fragmentation that rapidly increases resistance and shortens device lifetime. In this work, we identify the governing mechanisms of Ag NW breakup and quantify its kinetics from the first detectable damage in an intact wire to complete separation into nanoparticles. We combined scanning electron microscopy (SEM), transmission electron microscopy (TEM), and molecular dynamics (MD) simulations to track the evolution of surface roughening, necking, and particle formation during thermal exposure. To investigate a large amount of data, we implement a computer-vision-based program that detects individual wire fragmentation, tracks Length changes in NWs, and converts image series into statistical data. This enables large-scale characterization across tens of thousands of individual fragmentations under multiple thermal loading scenarios, including time-dependent heating protocols. The resulting fragmentation maps reveal a strong and systematic dependence on heating duration. By correlating microscopy results, automated statistics, and MD, we demonstrate that surface diffusion of Ag atoms is the primary driving force behind changes in morphology and the degradation process. From the measured distributions, we extract characteristic timescales and stability conditions for long-term operation of Ag NW networks. These insights provide a predictive basis for improving the thermal stability of Ag NW-based transparent conductors and flexible devices.

POSTER 10 – SESSION B

Host-derived metabolites as a signal for intracellular pathogen replication and virulence

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The modern era of antibiotics began with Sir Alexander Fleming's discovery of penicillin, revolutionizing the treatment of infections. Antibiotics have not only saved lives but also played a pivotal role in major advances in medicine and surgery, revolutionizing modern medicine. They have successfully prevented or treated infections that can occur in patients who are receiving chemotherapy, who have chronic diseases such as diabetes, end-stage renal disease, or rheumatoid arthritis, or who have had complex surgery such as organ transplants, joint replacements, or cardiac surgery. Excessive use of antibiotics has caused bacterial resistance, and no new classes of antibiotics have been discovered since the 1970s. The emergence of bacterial resistance to antibiotics threatens to cause a regression to the pre-antibiotic era, as the treatment of infections with the available arsenal of clinically used antibiotics has been severely affected by the emergence of multidrug-resistant strains. Macrophage cells are vital innate immune cells that identify, engulf, and destroy pathogens. Despite these functions, many bacteria have evolved strategies to survive within macrophages rather than be eliminated. Through long-term evolutionary adaptation, pathogens such as *Salmonella* exploit the intracellular environment of macrophages as a protective niche, allowing them to evade immune attack, resist killing mechanisms, and establish persistent infection inside host cells. Our understanding of the intracellular lifestyle and the limited effectiveness of antibiotics remains poorly established. Recent studies connect bacterial virulence and survival to the detection of host-derived metabolites, such as succinate, which signals for an enhanced adaptive response and increased virulence. It has been proposed that intracellular *Salmonella* exploits host succinate as a signal to activate expression of virulence and antimicrobial resistance genes. However, we show here that, in laboratory cultures, succinate is not a specific signal but rather provides a nonspecific metabolic boost to *Salmonella* by downregulating RpoS. This effect has limited significance in vivo as a *Salmonella* mutant lacking all seven succinate transporters exhibits unaltered proteome-wide properties in systemically infected mice. Our research highlights the importance of developing genetic tools and using model organisms in infection biology research, while challenging conclusions drawn from recent studies based solely on laboratory conditions.

POSTER 11 – SESSION C

Dinucleotide-Dependent Control of att-Site Specificity in Bxb1 Integrase

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Bxb1 integrase is a serine recombinase that catalyzes directional recombination between specific bacterial and phage attachment sites (attB and attP sites, respectively). By binding to attB and attP sites, recombinases generate staggered double-strand breaks at a central 2-bp dinucleotide crossover region. The central 2-bp dinucleotide pair within the crossover region of the attachment sites acts as the primary determinant of site orientation and interaction orthogonality, allowing for specific recombinase activity without cross-reactivity. While it is sometimes acknowledged that palindromic dinucleotide sequences in the crossover region may cause unintended inversion, other dinucleotide pairs (e.g. GA and GT) in crossover regions are considered highly specific and therefore orthogonal att-sites can be used for multiplexed genome and plasmid engineering without unwanted side reactions. Bxb1 integrase has been shown to perform efficiently and with excellent compatibility between orthogonal sites, as exemplified by the site-specific recombination-based tandem assembly or SSRTA (Wang et al., 2017 PMID: 27864282) *in vitro*. However, during the development of a Bxb1-based methodology for metabolic engineering in *E. coli*, we identified several non-specific side reactions occurring between supposedly orthogonal att sites. To investigate the specificity of Bxb1 integrase *in vivo*, we engineered a two-plasmid fluorescent reporter system (mRFP1/sfGFP) to monitor recombination between attB and attP variants. In this architecture, one plasmid provides inducible expression of the Bxb1 integrase, while the second serves as a reporter, harboring both att sites and a recombination reaction-dependent expression of mRFP1 or sfGFP. In the reporter plasmid, a constitutive promoter is placed between attB and attP sites and it constitutively drives the expression of mRFP1. Once the expression of Bxb1 is induced, the promoter region can be inverted by the recombinase, triggering the synthesis of sfGFP. Through FACS analysis, we evaluated how att site orientation and central dinucleotide crossover regions influence excision and inversion by Bxb1 integrase. We observed that even a single-nucleotide overlap is sufficient to enable recombination, with GC overlaps exhibiting higher efficiency than TA overlaps. Furthermore, we also identified that partial complementarity between crossover regions may also disrupt recombination directionality promoting excision over inversion. These findings provide a framework for selecting minimally interfering att-sites facilitating more precise metabolic engineering and synthetic circuit design in *E. coli*. This study also elucidates att-site specificity of the widely utilized Bxb1 integrase, providing a valuable framework for recombinase-based design.

POSTER 12 – SESSION C

Advancing Threshold-Inception Modeling for Predictive Simulation of Ionic Wind Fan Performance

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Electroaerodynamic (EAD) or electrohydrodynamic (EHD) airflow generation offers a promising solid-state alternative to conventional fans by producing ionic wind without moving parts. However, predictive numerical modeling of ionic wind devices remains challenging because of the strong coupling between electrostatics, charge transport, corona discharge, and fluid flow. In this work, a fully coupled multiphysics model based on a threshold-inception formulation is developed and validated against experiments for a wire-to-cylinder ionic wind fan operated under atmospheric conditions. The model combines electrostatics, drift-diffusion charge transport, and laminar flow, with ionization introduced dynamically once the local electric field exceeds the corona inception threshold. Experimental measurements were performed for three emitter-to-collector gaps, 5, 10, and 15 mm, over a range of applied voltages. The model reproduced the main observed trends in airflow generation and provided good qualitative agreement with measured airspeed and performance behavior across all configurations. The highest measured outlet velocity was 1.55 m/s at a 10 mm gap and 11.4 kV, corresponding to an estimated thrust of 16.3 mN and an overall efficiency of 0.36%. Systematic discrepancies nevertheless emerged at higher voltages and larger electrode gaps. Analysis of scanning electron microscope images of the Nichrome emitter wire revealed longitudinal surface protrusions of approximately 2 μm , indicating that the commonly assumed smooth-electrode approximation does not adequately represent the real emitter morphology. When representative protrusions were incorporated into the numerical geometry, local electric-field enhancement increased charge injection and improved agreement between simulations and experiments, especially in regimes where the baseline model underpredicted airflow. The results demonstrate that threshold-inception modeling provides a robust engineering-oriented framework for simulating ionic wind fans, but also show that micro-scale electrode surface morphology is a critical parameter for predictive accuracy. The study therefore identifies realistic emitter geometry as an essential consideration in the development of reliable simulation tools for EAD devices used in airflow generation, active cooling, electrostatic air handling, and aerodynamic flow control.

POSTER 13 – SESSION C

Variation in weather conditions have significant effects on winter wheat flag leaf stomatal traits

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Stomata, the gatekeepers on the leaf surface, regulate gas diffusion between the leaves and the atmosphere. In cereals, stomata consist of two guard cells and subsidiary cells surrounding them. They open and close in response to environmental factors. Wheat (*Triticum Aestivum*) is an ancient and most widely cultivated food crop that plays a crucial role in feeding the world's population. In wheat, the flag leaf is an essential organ that determines grain filling duration and final grain yield. Changes in environmental conditions, such as rising temperatures, droughts, or excess rainfall, cause stress in plants and reduce grain yield. Although there are numerous studies on stomata in cereals, those on wheat and the relationships between wheat stomatal traits and grain yield under field conditions are still not well understood. Therefore, the aim of our study was to investigate stomatal morphological and physiological traits, their relationship with grain yield under field conditions, and the effect of flag leaf removal on grain yield components. We conducted a three-year field trial (2023-2025) with 25 winter wheat varieties in three replications. From each plot, we randomly selected six plants for measurements and six plants as control plants. We measured stomatal conductance (gs) with a porometer and removed the flag leaf. After removing the flag leaves, we made leaf imprints for stomatal density (SD) and size. In 2025, we included ten spring wheat varieties as a comparison. We also performed yield component analyses (spike length, grain number spike⁻¹, grain weight spike⁻¹). Field trial results showed that SD was higher in the warm 2023 than in the cooler and wetter 2025, when gs was higher. Lower SD in 2025 was mainly due to a larger leaf area in 2025, leading to more widely spaced stomata. Although weather conditions influenced SD and gs, stomatal distribution between the leaf upper and lower surfaces was only affected by genotype. Results also showed that grain yield was lower in 2025 than in 2023 and 2024, which might be related to extreme cold waves during the active spring growth period. We found a positive relationship between leaf upper-side SD and grain yield in warm, dry 2024 and in cooler, wetter 2025, but not in 2023. Across the trial years, genotypes with smaller stomata exhibited higher grain yield. The removal of the flag leaf in winter wheat moderately lowered grain weight spike⁻¹ in the pooled data and in 2025. In contrast, flag leaf removal in spring wheat in 2025 resulted in both decreased grain weight spike⁻¹ and grain number spike⁻¹, with more pronounced declines than in winter wheat. As unfavourable environmental conditions for plant growth and development become more frequent due to climate change, these results provide important insights for plant breeders to develop wheat varieties that adapt to varying climate conditions while maintaining high grain yields.

POSTER 14 – SESSION C

Fatty-acid modified peptide nanocomplexes for the delivery of CRISPR/Cas9 RNP

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Since their initial discovery, CRISPR technologies have advanced at an exceptional pace, driving growing enthusiasm for their therapeutic potential. Yet, the translation of these systems into clinical applications remains limited by the lack of delivery vectors that combine safety, specificity, and efficiency. To address these constraints, a range of novel delivery platforms are under development, including cell penetrating peptides (CPPs). CPPs are inherently capable of traversing cellular membranes and can self-assemble into nanocomplexes with a diverse range of cargos to elicit bioactive delivery. Furthermore, CPPs can be engineered through various chemical modifications, including lipidation, sequence engineering, and ligand conjugation, to enhance their delivery efficiency and functional versatility. In this study, we systematically evaluated how N terminal saturated fatty acid tail length modulates the performance of the PepFect14 (PF14) CPP in Cas9 ribonucleoprotein (RNP) delivery by varying fatty acid length from 2 carbons to 26 in 4 carbon increments - C2-C26. The physicochemical properties of PF14-RNP complexes were studied with dynamic light scattering, transmission electron microscopy and SYBRGold encapsulation assay, while membrane activity and endosomal release was assessed with hemolysis assay and confocal microscopy. Bioactivity was evaluated with flow cytometry and DNA sequencing. This work identifies fatty acid chain length as a critical regulator of nanoparticle assembly, cargo protection and delivery. Our results show that long chain PF14 analogs (\geq C22) form compact, positively charged nanocomplexes that shield the RNP and support efficient uptake and endosomal escape, whereas short chain variants fail to produce stable nanocomplexes and exhibit negligible activity. Importantly, the optimized PF14 variants enable high editing efficiency in reporter cell lines and on endogenous PCSK9 gene target using a minimal, chemically defined formulation—without the need for auxiliary lipids, polymers, or covalent conjugation. Together, this work demonstrates that strategic hydrophobic modifications of PF14 substantially enhance RNP delivery and positions long chain acylated PF14 analogs as promising non viral carriers for CRISPR/Cas9 RNP.

POSTER 15 – SESSION C

Philosophy and Power in Smart Cities: A Systematic Literature Review

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This article provides a thorough overview of philosophical, ethical, and critical-theoretical viewpoints on smart cities and urban technology governance. A structured search technique was used across major academic databases to analyse peer-reviewed material produced between 2010 and 2025, in accordance with PRISMA principles. The review combines insights from philosophy, ethics, critical theory, and discourse analysis, including Foucauldian approaches to power and government. The findings indicate that, while ethical issues such as surveillance, privacy, and algorithmic decision-making are extensively debated, deeper philosophical and critical involvement is limited and dispersed. In particular, Foucauldian and discourse-analytic perspectives illustrate how smart city narratives develop new forms of government and socio-technical control. The paper analyses key topic areas and reveals substantial gaps in the integration of critical theory into smart city research, advocating for more theoretically grounded methods to comprehending the normative and political dimensions of digital urbanism.

POSTER 16 – SESSION C

Comparative evaluation of CRISPR/Cas9 RNP and mRNA delivery mediated by hydrophobically modified cell-penetrating peptides in cellular gene editing models

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The “Clustered Regularly Interspaced Short Palindromic Repeats associated protein 9” (CRISPR/Cas9) system is a powerful DNA-editing tool, has enabled precise genetic modifications and gained widespread prominence across diverse disciplines. However, its clinical translation is hindered by delivery barriers, including large molecular size, negative charge, poor stability, immunogenicity and off-target effects. Cell-penetrating peptides (CPPs) are promising non-viral carriers that offer a compelling solution to overcome these barriers. CPPs can spontaneously self-assemble with CRISPR components through non-covalent interactions, forming stable complexes that protect the cargo during transit and facilitate its intact release upon cellular entry, without compromising cell viability or membrane integrity. Yet whether CPPs can deliver Cas9 RNP and Cas9 mRNA in both formats and if the overall delivery efficacy could be improved remains elucidated. Building on the established role of fatty acid modifications in CPP-mediated delivery, this study varied the N-terminal acyl chain length of PepFect14 (PF14) from C2 to C26 to determine how hydrophobicity modulates CRISPR/Cas9 delivery and gene-editing outcomes. For detailed evaluation of the impact of hydrophobicity, a series of PF14 analogues were synthesized and studied for their ability to form nanoparticles (NPs) independently with either Cas9 RNP or Cas9 mRNA. Among the selected analogues, PF14-C26 bearing the longest fatty acid tail in the series achieved stable and uniform nanoparticle formation with both Cas9 formats, as confirmed by physicochemical characterization, achieving high encapsulation efficiency and effective cargo complexation. In contrast analogues with shorter fatty acid tails exhibited comparatively weaker complexation and reduced colloidal stability. The extended acyl chain appears to enhance hydrophobic interactions during self-assembly and membrane interaction, contributing to improved complex stability and cellular internalization. Functional evaluation in HEK293T SL reporter cells confirmed that PF14-C26 facilitated gene-editing activity across both Cas9 formats, demonstrating its capacity as a versatile delivery vehicle regardless of CRISPR format. Nevertheless, notable differences in editing efficiency between the two formats suggest that while acyl chain elongation broadly enhances CPP-mediated delivery, the choice of CRISPR format remains a critical determinant of gene-editing outcomes. Collectively these findings pave the way for the rational development of fatty acid modified CPP-based CRISPR delivery platforms with potential for safe and effective therapeutic gene editing.

POSTER 17 – SESSION C

Investigating the role of MAGEA10 in dynamic cellular behaviour using live-cell imaging

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Cancer/testis antigens (CTAs) are aberrantly expressed in many cancers but largely restricted to the testis in normal tissues. This limited normal expression, combined with high immunogenicity, makes them attractive targets for cancer immunotherapy. The MAGEA family is among the most studied CTAs, with members implicated in regulating tumour cell proliferation, migration, and colony formation across multiple cancer types. MAGEA10 is one of the most immunogenic MAGEA members, yet its biological function remains largely unexplored. This study investigates how MAGEA10 influences dynamic cellular behaviour in real time. To investigate MAGEA10's influence on dynamic cellular behaviour, we transiently overexpressed it in MRC5 human embryonic fibroblasts. Cells were monitored over time using the EVOS M7000 live-cell imaging system. Preliminary findings indicate that MAGEA10 overexpression alters cellular movement behaviour compared with control cells, suggesting a functional role for MAGEA10 in regulating cell motility. Given that MAGEA10 is overexpressed across multiple cancer types, characterising its influence on cellular dynamics provides functional insight into how this protein may contribute to tumour cell behaviour.

Our sincere thanks to everyone involved in organizing and participating in this conference. Your efforts have created a platform for meaningful exchange and learning.

With appreciation on behalf of the organizing team,

Margit Mutso

Ingrid Rebane

Siiri Oras

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