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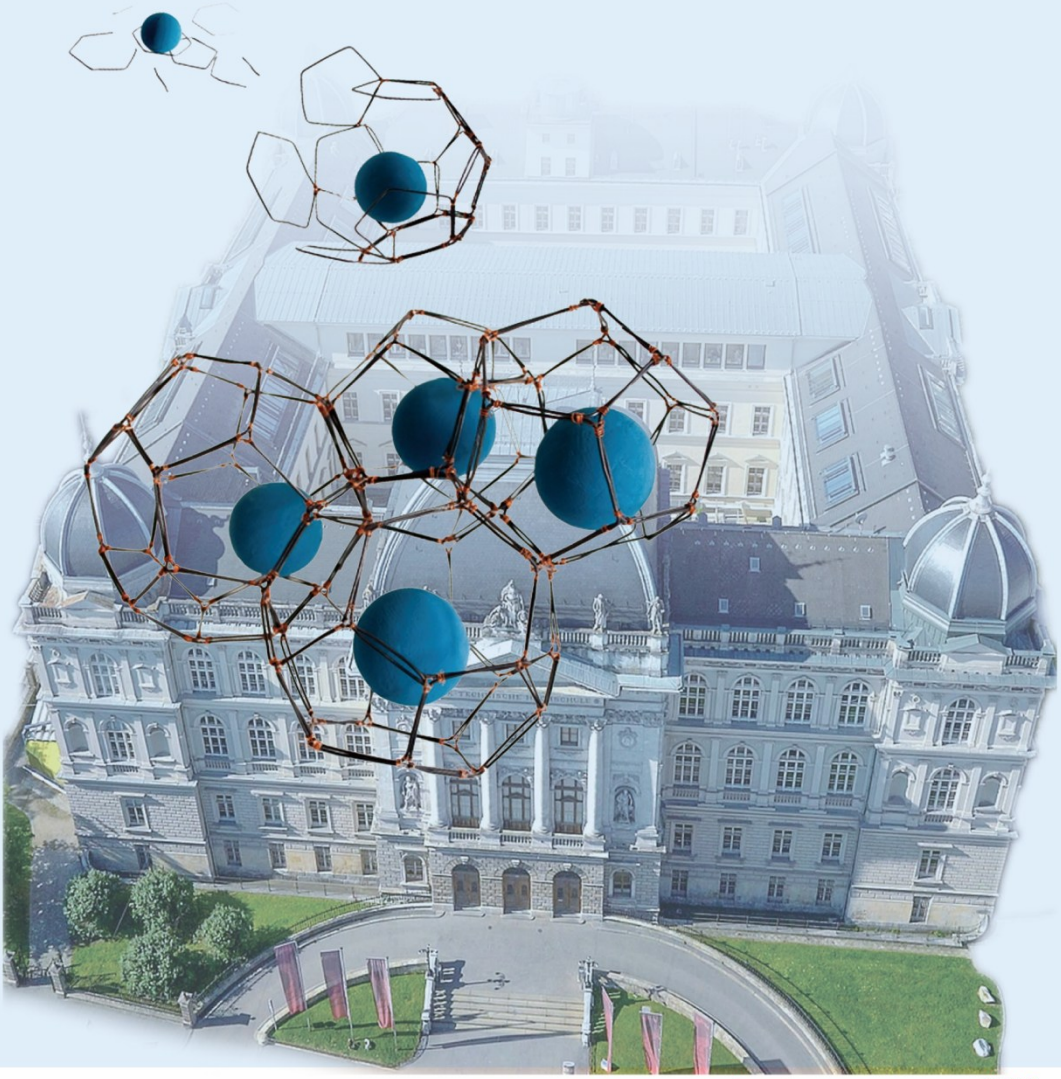

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Timetable

18th September		19th September	
09:00	Opening Remarks	08:30	Niveen M. Khashab
09:10	Fa-Kuen Shieh	09:10	Yong Cui
09:50	Christian Doonan	09:50	Jeremiah Gassensmith
10:30	**Coffee break**	10:30	**Coffee break**
11:00	Mónica Giménez-Marqués	11:00	Hana Bunzen
11:40	Joe Patterson	11:40	Inose Tomoko
12:20	**Lunch**	12:20	**Lunch**
14:00	Yue-Biao Zhang	14:00	Lien-Yang Chou
14:40	Weibin Liang	14:40	Giovanna Brusatin
15:20	**Flash Presentations**	15:20	Mathilde Lepoitevin
16:00	**Poster Session**	16:00	**Concluding remarks and poster session**

Map

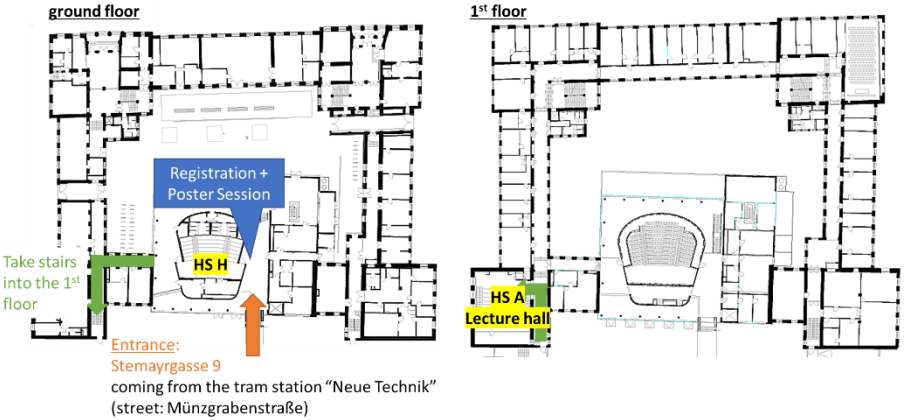
General

Main entrance: Stremayrgasse 9
O Registration and lecture hall
O Tram station "Neue Technik"
→street: Münzgrabenstraße

● grocery store "SPAR"

● Example of restaurants near-by
A … Pho You (Vietnamese)
B … Unterm Goldenen Dachl (local food)
C … Auer (Bakery)
D … Pizzaiolo (Italian food)
E … Mensa (TU cafeteria)

Venue: Registration and Lecture Hall



Instructions

Poster presentations: Posters can be placed starting from *18th September at 8:30 am* in front of the HS H.

Oral presentations: If you wish to use the lecture hall computer, please provide both a ***.pdf*** and a ***.pptx*** version of your presentation. Upload your files either *in the morning or during the lunch break* of the day of your presentation.

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Weibin Liang
University of Sydney

Yue-Biao Zhang
Shanghaitech University

Christian J. Doonan
University of Adelaide

Event Schedule

Thursday 18th September

Registration: 17th Sept. from 3:00-4:30pm and on 18th Sept. from 8:30pm	
09:00	**Opening Remarks**
Chair: Paolo Falcaro	
09:10	**Fa-Kuen Shieh** *National Central University* Insights into MOF Chemical Biology: Biocatalysts Encapsulated within MOFs
09:50	**Christian Doonan** *University of Adelaide* From MOFs to HOFs: Encapsulation of Biomacromolecules in Framework Materials
10:30	**Coffee break**
Chair: Hana Bunzen	
11:00	**Mónica Giménez-Marqués** *University of Valencia* Expanding the Structural and Functional Space of Biomolecule–MOF nanohybrids
11:40	**Joe Patterson** *University of California* Quantifying the aggregation and spatial distribution of proteins within metal-organic frameworks
12:20	**Lunch**
Chair: Jia Min Chin	
14:00	**Yue-Biao Zhang** *Shanghaitech University* Multivariate Metal Azolate Frameworks for Biocomposites
14:40	**Weibin Liang** *University of Sydney* Opportunity in Machine Learning-Optimizing Synthesis of Metal-Organic Framework Based Biocomposite
15:20	**Flash Presentations**
16:00	**Poster Session**

Friday 19th September

Chair: Francesco Carraro	
08:30	**Niveen M. Khashab** *King Abdullah University* Coordination and Self-Assembled Capsules (SACs) for Precision Medicine and Agriculture
09:10	**Yong Cui** *Shanghai Jiao Tong University* Crystallizing Chirality—Single Crystals of Hybrid Porous Materials
09:50	**Jeremiah Gassensmith** *University of Dallas* *Metals Maketh The Difference*
10:30	**Coffee break**
Chair: Mónica Giménez-Marqués	
11:00	**Hana Bunzen** *University Magdeburg* Beyond Conventional Imaging: Metal–Organic Frameworks for Magnetic Resonance Applications
11:40	**Inose Tomoko** *Kyoto University* Integration of photo-responsive porous materials with plasmonic nanowires for intracellular molecular delivery
12:20	**Lunch**
Chair: Sandro Keller	
14:00	**Lien-Yang Chou** *Shanghaitech University* Overcoming Enzyme-MOF Integration Barriers: Enzyme Surface Engineering and Mild Aqueous Solid-State Encapsulation
14:40	**Giovanna Brusatin** *University of Padova* Engineering the cell microenvironment and tissue architecture to mimic the in vivo physical forces in health and disease
15:20	**Mathilde Lepoitevin** *Ecole Normale Superieure* Iron-Based MOFs for Antibacterial Therapy and Wound Healing
16:00	**Concluding remarks and poster session**

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T07 Khashab N. M.

T08 Cui Y.

T09 Gassensmith J.

T10 Bunzen H.

T11 Tomoko I.

T12 Chou L.-Y.

T13 Brusatin G.

T14 Lepoitevin M.

T1

Insights into MOF Chemical Biology: Biocatalysts Encapsulated within MOFs

Fa-Kuen Shieh*

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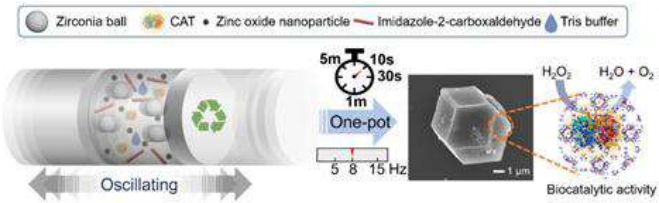
Metal-organic frameworks (MOFs) have found diverse applications in bio-sensing, biomass utilization, and catalysis. This study introduces a novel concept in material biology known as MOF Chemical Biology. It focuses on investigating the impact of containing biomolecules, such as protein enzymes, within synthetic MOF biocomposites, referred to as enzyme@MOFs. These biocomposites are prepared using a *de novo* biomineralization synthesis route, conducted under mild and aqueous conditions. The framework of these biocomposites possesses apertures that enable the free movement of substrates, while the encapsulated enzymes or bacteria remain confined within the structure, thereby shielding them against most structural changes.

Furthermore, we present the first successful demonstration of encapsulating enzymes into robust Zirconium-based MOFs, specifically UiO-66, using a solid-state mechanochemical process. The enzymes encapsulated through this method retain their desired functionality and exhibit resistance to proteases, even under acidic conditions. These innovative approaches provide an alternative system, exploiting the structural confinement effect, for expanding the application of MOFs in studying the biochemical functionalities of prokaryotes, eukaryotes, mammalian cells, and more.[1-8]



***Green and Ultrafast One-Pot Mechanochemical Approach for Efficient Biocatalyst Encapsulation in MOFs*[3]**

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T2

From MOFs to HOFs: Encapsulation of Biomacromolecules in Framework Materials

Christian J. DOONAN
School of Physics, Chemistry and Earth Sciences
Faculty of Sciences, Engineering and Technology
University of Adelaide, Australia

This talk will canvass our work on understanding the encapsulation of Biomacromolecules in metal-based framework materials (MOFs) to metal free hydrogen-bonded frameworks (HOFs).

Expanding the Structural and Functional Space of Biomolecule–MOF nanohybrids

Mónica GIMÉNEZ-MARQUÉS[1], Jesús CASES-DíAZ[1] Jana GLATZ[1]
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The integration of biomacromolecules within metal–organic frameworks (MOFs) has emerged as a powerful strategy to stabilize fragile biological entities, thereby enabling their use in diverse biomedical and biotechnological applications.[1] This process, often achieved through biomolecule-driven MOF mineralization, relies on mild synthetic conditions and favorable biomolecule–MOF interfacial interactions. To date, however, the scope of biohybrid synthesis has remained largely confined to zeolitic imidazolate frameworks (ZIFs), limiting the diversity of structural and functional features that can be explored.

In this work, we expand the biohybrid family by establishing synthetic routes to non-ZIF MOFs, thereby accessing new modes of biomolecule mineralization.[2-4] These alternative frameworks not only broaden the structural diversity of biohybrids but also unveil previously inaccessible functionalities arising from their distinct compositions and architectures (Figure 1). This contribution highlights the importance of framework diversification as a pathway to tailor hierarchical organization and unlock novel properties in biomolecule–MOF nanohybrids.

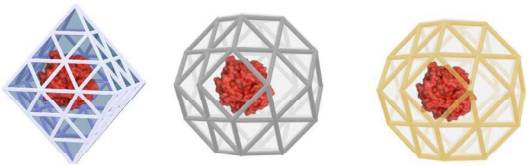

Figure 1: Schematic representation of structurally and compositionally diverse biomolecule@MOF nanohybrid.

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Quantifying the aggregation and spatial distribution of proteins within metal-organic frameworks

Joseph P Patterson[1]

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E-mail: patters3@uci.edu

Understanding how proteins are spatially organized within metal–organic frameworks (MOFs) is essential for advancing their use in catalysis, sensing, and therapeutic delivery. Yet, despite widespread interest in protein based MOF biocomposites, a detailed picture of how individual proteins are positioned and interact within these crystalline hosts has remained elusive. This gap limits our ability to design materials with predictable properties and performance. In this work, we address this challenge by developing an electron microscopy-based approaches that enable direct 3D visualization of protein encapsulation in MOFs. Our findings shed light on the connection between synthetic conditions and protein distribution, offering a blueprint for the rational design of functional biohybrid materials. This approach moves beyond indirect characterization, opening new avenues for understanding and engineering protein–material interfaces with precision.

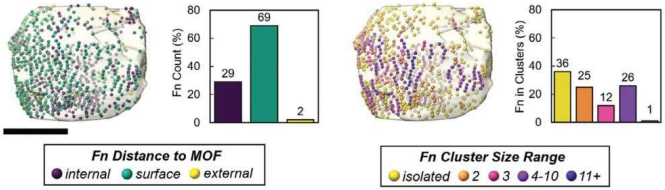

Figure 1. Visualization and quantification of the Fn protein aggregation and spatial distribution within ZIF-8

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T5

Multivariate Metal Azolate Frameworks for Biocomposites

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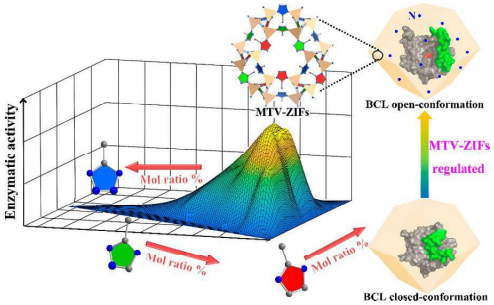
This talk presents the design of multivariate metal azolate frameworks (MTV-MAFs) for high-performance enzyme biocomposites. Conventional MOFs often suffer from small pores that limit catalysis with bulky substrates.

We synthesized large-pore MAF-6 (7.6 Å) by a visible-light-mediated method, enabling efficient encapsulation of lipase (BCL). The optimized BCL@MAF-6-SDS showed a 420-fold higher catalytic efficiency than BCL@ZIF-8 and excellent activity and enantioselectivity in asymmetric synthesis.

We applied an MTV strategy to tune pore microenvironments by varying linker ratios. A Component-Adjustment Ternary (CAT) method revealed a non-linear relationship between linker composition and enzyme activity, with the optimal ratio doubling BCL reactivity and enhancing stability and enantioselectivity.

These results highlight that combining large-pore design with MTV microenvironmental control provides a powerful strategy for developing robust enzyme@MOF biocomposites for biocatalysis and pharmaceutical synthesis.



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Opportunity in Machine Learning-Optimizing Synthesis of Metal-Organic Framework Based Biocomposite

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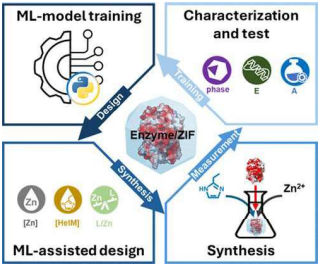

In recent years, enzyme/metal–organic framework (enzyme/MOF) biocomposites have attracted significant attention due to their straightforward preparation and promising functional performance.[1] These biocomposites can offer high encapsulation efficiency, retained enzymatic activity, and enhanced protection against environmental stressors.[2] However, achieving these desired properties is not always guaranteed.[3] Experimental studies reveal that factors such as crystallinity,[4] structural defects,[5] chemical microenvironment,[6] and enzyme spatial distribution[7] critically influence biocomposite performance. These structural attributes are, in turn, highly sensitive to synthesis conditions, including the choice of organic ligands,[8] reactant concentrations,[7] and ligand-to-metal molar ratios.[3]

Over the past decade, machine learning (ML) has emerged as a transformative tool in materials science, enabling accelerated discovery and optimization of materials with targeted properties. In reticular chemistry, ML-driven approaches have been successfully employed to refine synthesis parameters and enhance outcomes such as phase purity,[9] crystallinity,[10] and sorption characteristics.[11] ML has also proven effective in screening MOFs for specific applications like propane/propylene separation and identifying novel synthetic pathways.[12]

In this talk, I will present case studies highlighting the potential of ML-assisted strategies in the enzyme/MOF field to optimize immobilization performance.[13] The proposed ML framework not only streamlines the design of high-performing enzyme/MOF composites for biocatalysis but also holds promise for broader applications. Notably, this approach can be adapted to guide the encapsulation of a wide range of biomacromolecules—including DNA, RNA, glycans, and even whole cells—into MOFs.

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Coordination and Self-Assembled Capsules (SACs) for Precision Medicine and Agriculture

Niveen M. Khashab

King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

The beginning of the 21st century saw numerous protein/ peptide and RNA therapeutics both in the market and entering the final stages of clinical studies. The main advantages of these biologics over conventional drugs can be summarized by their high selectivity and potent therapeutic efficacy coupled with limited side effects. In addition, they exhibit more predictable behavior under in vivo conditions. However, up to now most of the formulations of biologics are designed and destined for the parenteral route of administration. As a consequence, many suffer from short plasma half-lives, resulting in their frequent administration and ultimately poor patient compliance. To address this shortcoming, researchers in both academia and industry started working on designing innovative encapsulation or delivery platforms for biologics especially after the recent pandemic. Similarly, a delivery challenge is seen in agricultural practices where huge amounts of pesticides and fertilizers are used in light of the need to meet the increasing food demands and improve nutritional content. In this talk, a new generation of smart encapsulation platforms based on reticular and supramolecular chemistry will be presented. These systems have shown superiority in encapsulating and protecting biological cargoes and nutrients with different size, charge, and solubility profile. We envision that this class of molecules can efficiently address many practical challenges in the field of encapsulation and controlled delivery and so can easily undergo translational scale up to be used in the market.

T8

Crystallizing Chirality—Single Crystals of Hybrid Porous Materials

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The precise crystallization of porous frameworks offers a unique platform to visualize and manipulate chirality at the atomic scale. Yet, growing large, high-quality single crystals of covalent organic frameworks (COFs) and related hybrids has remained an enduring challenge. Here we present recent advances in *crystallizing chirality* through hybrid strategies that unite covalent and coordination chemistry. By employing coordination-templated imine formation, we achieved the rapid synthesis of fourteen single-crystal MOF–COF (MCOF) hybrids within two days, enabling structural elucidation at sub-ångström resolution. These crystals reveal complex architectures, topological diversity, and atomic-level insights into host–guest interactions and chirality transfer. Extending this principle, we developed a one-pot confined growth strategy to generate single-crystalline metal–halide porous superlattices, in which 0D clusters, 1D chains, and 2D nanosheets are deterministically organized within zirconium-MOF scaffolds. Such superlattices display tunable photoluminescence and emergent chiroptical properties, highlighting the versatility of reticular templates in encoding multi-dimensional periodicities. Together with the broader framework of chiral reticular chemistry, these studies establish a unified approach to constructing homochiral crystalline solids with programmable structures and functions. .

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T9

Metals Maketh The Difference

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Metal-organic frameworks (MOFs) have been advanced as universal solutions in chemistry, promising everything from gas storage to miraculous drug delivery, depending on the funding climate. In this work, we apply MOFs to a problem that is both timely and enduring: the controlled delivery of biological macromolecules—proteins, nucleic acids, and, on occasion, entire cells—into biological systems.

Despite their reputation for versatility, MOFs are not without temperament. Our investigations reveal that the choice of metal node does more than determine structural robustness or porosity—it appears to dictate how the immune system will react. MOFs constructed from zinc and manganese (ZIFs) not only protect cargo but paradoxically provoke the immune system, serving as their own adjuvant and occasionally outperforming more established vaccine technologies in murine models [1]. In contrast, zirconium-based MOFs—often celebrated for their inertness and stability—induce the opposite response, delivering their payloads with minimal immune recognition.

This dichotomy has clarified the need for a more nuanced view of MOFs in biomedicine. Rather than treating MOFs as a single functional class, our work suggests that careful selection of metal composition enables tuning of immune visibility, ranging from highly immunogenic to nearly invisible. This has implications for vaccines, enzyme therapeutics, and any application where evasion or engagement of the immune system is not just desirable, but required.

The data presented will come in two tableaux that illustrate this outcome. First, I will discuss a new vaccine material for tuberculosis and show that MOFs based on Zn and Mn can effectively adjuvant an anti-tuberculosis response. Second, I will demonstrate that we can persistently release a small enzyme from MOF depots, both with and without significant immune recognition, depending on the MOF system. Ultimately, I hope to emphasize that MOFs are a platform that can allow for exceptional tailoring in biomolecule delivery, depending on the desired outcome.

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Beyond Conventional Imaging: Metal–Organic Frameworks for Magnetic Resonance Applications

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Metal–organic frameworks (MOFs) offer unique structural tunability, porosity, and chemical versatility, making them ideal platforms for advanced biomedical applications. In our group, we design and synthesize MOFs and MOF-based biohybrids with tailored porosity, surface chemistry, and stability for drug delivery, biosensing, and bioimaging. By combining biocompatible linker chemistry with external surface modifications, we engineer MOF nanoparticles for selective biomolecule binding, targeted transport, and controlled release.

To track nanoparticle distribution in biological systems, we employ both fluorescent labeling and magnetic resonance imaging (MRI, Figure 1). Traditional proton-based MRI faces challenges in specificity due to high endogenous background. To overcome this, we focus on heteronuclear MRI, specifically ^{19}F MRI, which provides background-free imaging because the detected signal originates solely from the administered fluorine-containing agents. We integrate fluorinated moieties into MOF nanoparticles and evaluate their performance as ^{19}F MRI imaging agents, assessing biocompatibility, stability, and signal intensity under physiological conditions. Furthermore, we explore pH-sensitive MOFs as ^{19}F MRI reporters for tumor microenvironments, demonstrating the potential of MOF biohybrids as multifunctional platforms for simultaneous diagnostic and therapeutic applications.

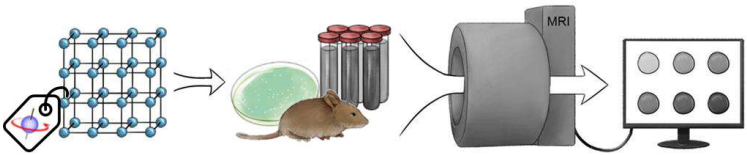

Figure 1. An illustration depicting MRI-tagged MOFs, showcasing the integration of magnetic resonance imaging with metal-organic frameworks for particle visualization.

Acknowledgement: Financial support by the University of Augsburg (Program: „Forschungspotenziale besser nutzen!“, Project: 2023-07) is gratefully acknowledged.

Integration of photo-responsive porous materials with plasmonic nanowires for intracellular molecular delivery

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Technologies for controlling cellular functions are gaining increasing attention, from fundamental biological research to biomedical applications. A key requirement for precise control of cellular behaviour is the ability to deliver functional biomolecules into living cells with high spatial and temporal precision. Among various delivery systems—such as liposomes, viral vectors, or electroporation—nanoprobe technologies uniquely enable single-cell-level manipulation with minimal invasiveness and high precision.[1][2] These nanoprobes provide direct intracellular access with lower cytotoxicity, offering a promising platform for localized biomolecular delivery.

Despite their potential for spatiotemporally controlled delivery, conventional nanoprobe-based methods have primarily focused on stable materials, such as quantum dots. Applications to biologically relevant but structurally labile species, such as gasotransmitters or proteins, remain limited. To address this, integrating nanoprobes with functional materials that can stabilize and release sensitive biomolecules under controlled conditions is essential. Hybrid systems combining nanoprobes with advanced carrier molecules could significantly broaden the scope of intracellular delivery and enhance their utility in biomedical research.

In this work, we developed an intracellular delivery platform by integrating photoresponsive porous materials with plasmonic silver nanowires. Porous materials such as metal-organic frameworks (MOFs) feature highly tunable pore structures and surface chemistry, enabling stable encapsulation of labile biomolecules—including gas molecules and proteins—that are challenging to handle in biological systems.[3][4] As a proof-of-concept, we demonstrated that a nitric oxide-releasing MOF (NOF-1) could be coated on silver nanowires and introduced into single live cells. Upon photoactivation, intracellular NO release was successfully achieved. This result highlights the potential of combining nanoprobes with photoresponsive functional materials for the controlled intracellular delivery of unstable compounds. We will also present recent efforts toward protein delivery using protein-encapsulated ZIF-8 integrated with nanowires, expanding this approach to a broader class of biomolecular cargos.

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Overcoming Enzyme-MOF Integration Barriers: Enzyme Surface Engineering and Mild Aqueous Solid-State Encapsulation

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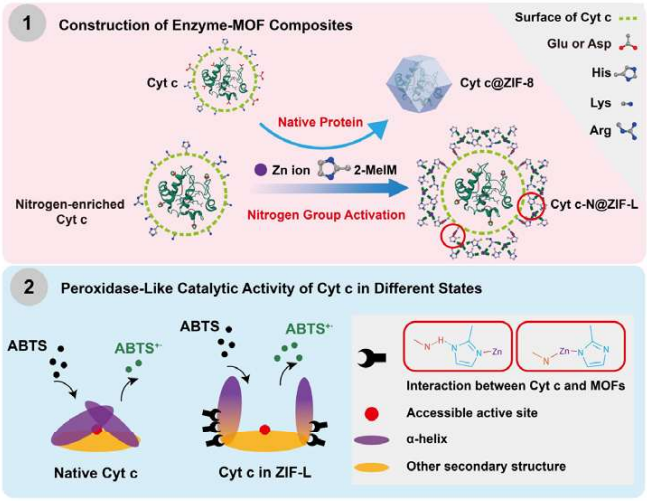
Enzymes suffer from significant instability under non-ideal conditions, exhibiting rapid activity loss and high susceptibility to environmental stresses. Integrating Metal-Organic Frameworks (MOFs) with biological entities offers a promising strategy to enhance their stability and efficiency for biomedical and environmental applications. However, challenges persist in MOF-biological entity integration, including limited bioactivity, synthesis complexity, and mass diffusion limitations arising from intrinsic MOF nanopores. Furthermore, the intricate structure-activity relationship between enzymes and MOFs, coupled with the enzymes' high sensitivity to conventional MOF synthesis conditions, restricts both the bioactivity of bio-MOF composites and the generality of the approach. To address these challenges, we developed two strategies. First, we optimized the encapsulation method by employing enzyme surface modification to facilitate encapsulation and induce a structural transition from conventional nanoporous to mesoporous frameworks [1]. Second, we applied an aqueous solid-state transformation to effectively integrate enzymes into robust Zr-based metal-organic frameworks, circumventing the typically required harsh synthesis conditions.



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Engineering the cell microenvironment and tissue architecture to mimic the in vivo physical forces in health and disease

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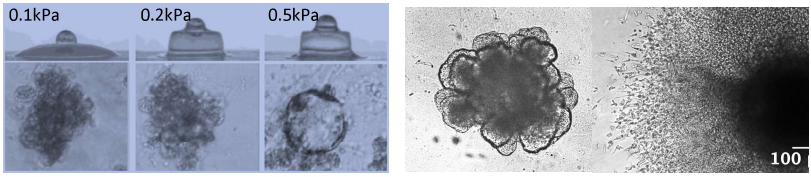
Mechanotransduction, which is broadly defined as the process by which cells convert mechanical cues from their environment into biochemical signals, is a fundamental driver of cell behaviour. It influences processes ranging from migration and differentiation to tissue homeostasis and disease progression. Recent advances in the study of cellular mechanotransduction rely on a multidisciplinary approach, combining biology with engineering and materials science. This approach far surpasses the limitations of traditional 2D cell culture models grown on rigid plastic Petri dish substrates. Advancing the basic biology of mechanotransduction and its clinical translation requires developing cell culture systems that mimic the natural cell microenvironment. At the seminar, I will introduce examples of engineered microenvironments, including micropatterned substrates and 2D or 3D soft hydrogels with controlled rigidity, degradability and adhesion properties. These chemically defined microenvironments enable the study of the mechanoregulation of cells using mechanotranscriptional regulators, YAP and TAZ, as molecular beacons of the cellular response. Finally, I will present our recent results on a 4D compartmentalised tumour-stroma ecosystem designed to mimic tumour evolution.
Emerging opportunities in these areas will be discussed.



Left) In-vitro embedding of acinar pancreatic cells expressing KRAS mutation in hyaluronic acid-based matrices. Cells embedded in stiff matrix exhibit progenitor marker expression (preneoplastic condition) as opposed to those embedded in soft matrices (0.1 kPa) which remained fully differentiated healthy cells.
Right) MCF10A cells and HER2+ expressing MCF10A tumor cells grown in a matrigel-free suspension mimicking the basement membrane. Inducing the growth of healthy organoids or an invasion process by tumor cell.

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Iron-Based MOFs for Antibacterial Therapy and Wound Healing

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Iron-based metal-organic frameworks (Fe-MOFs) have emerged as highly promising candidates in biomedical applications[1] due to their intrinsic biocompatibility, high drug-loading capacity, biodegradability, and ability to generate reactive oxygen species (ROS). Since joining IMAP, my research has focused on harnessing these unique properties for therapeutic strategies against antibiotic-resistant infections[2] and cancer.[3] In particular, we explore the potential of Fe-MOFs for targeted drug delivery, ferroptosis-induced cancer therapy, and antimicrobial treatments. Despite their potential, challenges such as biological stability, toxicity at high concentrations, and scalability must be overcome to enable clinical translation. Our work addresses these limitations through the development of eco-friendly synthesis methods and surface functionalization strategies. [4]
In this presentation, I will highlight two recent advances in the development of iron-based metal-organic frameworks (Fe-MOFs) for antibacterial therapy and wound healing. First, MIL-100(Fe)@IR775 nanoparticles, synthesized via a green method, exhibit outstanding photostability and potent photothermal/photodynamic antibacterial activity under LED irradiation, effectively eradicating methicillin-resistant Staphylococcus aureus (MRSA) and accelerating wound healing both in vitro and in vivo.[5] Second, we developed dissolvable microneedles incorporating AuNCs@MIL-100(Fe) nanocomposites, which harness the synergistic effects of chemodynamic and photodynamic therapies to combat MRSA through enzyme-like cascade reactions and light-activated reactive oxygen species generation. Together, these findings underscore the versatility of Fe-MOFs in engineering multifunctional, smart therapeutic platforms and highlight their promise as next-generation solutions for drug-resistant infections and wound care.

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Poster Presentations

P01 Strasser N.

P02 Li A.

P03 Borrego E. (Poster + Flash presentation)

P04 Lipic V.

P05 Afanasenko E.

P06 Zojer E.

P07 Rubio-Giménez V. (Poster + Flash presentation)

P08 Eggenreich L. (Poster + Flash presentation)

P09 Debas M.

P10 Zhao Y.

P11 Yang J. (Poster + Flash presentation)

P12 Davies J. (Poster + Flash presentation)

P13 Piller P. (Poster + Flash presentation)

P14 Alotaiby S.

P15 Zeng W. (Poster + Flash presentation)

P16 Li X.

P17 Torresan V.

P18 Knaipp K.

P19 Kowacz G. (Poster + Flash presentation)

P20 Schmallegger M.

P1

The Role of Chemical Bonding and Hydration State on the Thermal Expansion of a Zinc-Based Metal-Organic Framework

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Thermal expansion is a fundamental material property that provides direct insights into the bonding forces within a solid. For metal-organic frameworks (MOFs), thermal expansion plays an important role, as their hybrid nature leads to diverse bonding motifs that can result in a highly anisotropic behavior. [1] However, to date, no experimental studies have systematically explored, how various types of chemical bonding affect anisotropic thermal expansion.

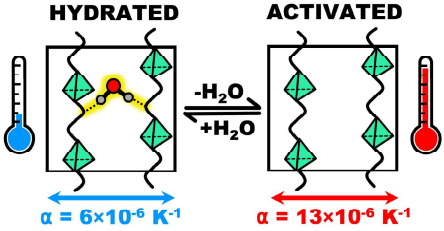

Figure 1. Dehydration of the MOF removes hydrogen bonds, which causes a doubling of the thermal expansion coefficient (α) in this direction, highlighting the pivotal role of hydrogen bonding in suppressing structural flexibility.

In our most recent study [2], we investigated the thermal expansion of GUT-2 – a zinc-based coordination polymer consisting of Zn^{2+} ions and 3-(2-methyl-1H-imidazol-1-yl)propanoate linkers [3] – by performing temperature-dependent powder X-ray diffraction measurements on activated and hydrated powder samples. It was found, that the hydrated structure displays near-zero thermal expansion along the direction of the polymer chains ($\approx 2\times10^{-6}$ K^{-1}), reflecting the rigidity imposed by strong covalent bonding. In contrast, moderate expansion ($\approx 6\times10^{-6}$ K^{-1}), is observed along the hydrogen-bonded direction, while the highest thermal expansion coefficient ($\approx 13\times10^{-6}$ K^{-1}), is found in the van der Waals bonding direction.

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Aqueous Two Phases Systems Mediated Hollow MOF Synthesis for Encapsulating Living Bacteria

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Microorganisms serve as potent biocatalysts with immense potential in biomedicine, pharmaceutical synthesis, environmental science, and industrial manufacturing[1]. However, their inherent fragility hampers resistance against harsh environmental stressors. Inspired by recent advances in bio-mineralization on enzymes, this study developed a microfluidic strategy based on aqueous two-phase systems (ATPS)[2] to synthesize hollow metal-organic frameworks (MOFs) for encapsulating living bacteria[3]. The technique employs poly (ethylene glycol)/dextran (PEG/DEX) to construct an all-aqueous interface, replacing traditional toxic organic solvents, and achieves *in situ* crystallization of ZIF-8 at the liquid-liquid interface under biocompatible conditions. Precise droplet size control (20–55μm) via microfluidic chips enables targeted bacterial encapsulation within MOF cavities. Confocal microscopy and plate counting demonstrated significantly enhanced survival of encapsulated E. coli using the ATPS-microfluidics approach (detectable viability) compared to conventional oil-water interfacial methods. Further validation with engineered bacteria carrying a heat-inducible promoter revealed intense mCherry red fluorescence expression within MOF cavities after 42°C induction, confirming preserved metabolic activity and protein synthesis capability. This work pioneers an ATPS-MOF bio-inspired encapsulation system, offering a novel platform to construct high-activity, robust living microbial biocomposites.

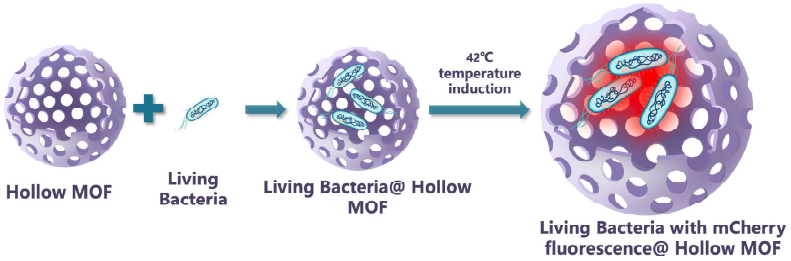

Figure 1. mCherry fluorescence emission from temperature-induced live bacteria encapsulated within hollow MOF

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Synergistic Reactivity and Crystal Phase Stability of Esterase@Zeolitic Imidazolate Framework Biocomposites

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The integration of biomolecules into protective materials is a key challenge in biotechnology. In this regard, metal-organic frameworks (MOFs) have enabled the creation of Bioentities@MOFs hybrid systems that merge the structural precision of MOFs with the functional complexity of biomolecules offering unique opportunities for applications [1]. This study explores the use of Zeolitic Imidazolate Frameworks (ZIFs) as protective coatings to enhance the stability and functionality of an esterase enzyme. Three different Esterase@ZIF biocomposites were synthesized by immobilizing pig liver esterase in the ZIF structure following natural biomineralization processes (Figure 1). The resulting Esterase@ZIF biocomposites showed exceptional crystal phase stability, preserving esterase activity even under harsh environments.

These Esterase@ZIF biomaterials exhibit a synergistic effect towards the degradation of a simulant nerve agent, diisopropylfluorophosphate (DIFP), under simulated biological conditions. Esterase@ZIFs possess higher nerve agent reactivity in comparison to its free constituents ZIFs and esterase at concentrations near the total inhibition of this enzyme. At the same time, organophosphate interaction with the crystal surface of the biocomposite triggers the structural degradation of Esterase@ZIF biocomposites, facilitating the release of nucleophilic 2-methylimidazole linkers, which hold significant potential for modulating enzymatic activity (Figure 1) [2]. Moreover, esterase incorporation into ZIF crystalline structure gives rise to a pronounced crystal phase stability, suggesting that the esterase hybrids contribute to the stabilization of the ZIFs crystal structure. The present work highlights the importance of the biomineralization process around sensitive biomacromolecules offering a promising platform for functional hybrid systems regarding their application in biocatalytic processes.

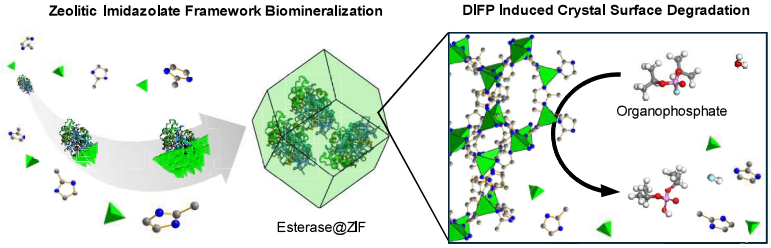

Figure 1. Schematic representation of biomineralization process of Zeolitic Imidazolate Frameworks (ZIFs) around esterase from mImH and Zn^{2+} precursors and organophosphorous induced crystal surface degradation.

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P4

enzyme@ZIF Biocomposites: Structural and Functional Impacts of 1-Methylimidazole-Induced Size Control

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Zeolitic imidazolate frameworks (ZIFs), a subclass of metal-organic frameworks (MOFs), are extended porous networks composed of metal ions (Zn^{2+}) and organic linking blocks (2-Methylimidazole (2-HmIm)). ZIFs can be synthesised under aqueous biocompatible conditions, rendering them suitable for encapsulation strategies. bio-based applications such as drug delivery, bio-preservation or biosensing.[1,2] Specifically, as demonstrated in previous studies, biomacromolecules have been shown to enhance the crystal growth, leading to the formation of enzyme@ZIF biocomposites.[3] The process of encapsulation is one potential solution that can be utilised for the purpose of protecting the enzyme from unfavourable environmental conditions, including elevated temperatures and denaturing agents.[2] Furthermore, it has been demonstrated that the conditions of synthesis can significantly impact crystal size and its topology. This, in turn, can have a direct effect on the enzymatic activity of the biocomposite. In general, smaller crystal sizes exhibit higher enzymatic activity compared to their larger counterparts with similar crystalline phase.[4] However, control over the particle size of biocomposites remains challenging. For example, additives used in organic syntheses (e.g., ammonia) can influence the activity of the encapsulated biomacromolecule.[2]

To address this challenge, we propose synthesising ZIF in the presence of 1-methylimidazole (1-HmIm), a biofriendly modulator which can influence the morphology, size [5] and consequently the catalytic performance [4] of the resulting biocomposite. In order to test this hypothesis, a multivariable system was investigated, incorporating three different ligand-to-metal ratios and varying amounts of 1-HmIm using Bovine Serum Albumin (BSA) serving as a model protein. The resulting BSA@ZIF particles were characterised in terms of chemical composition, crystalline phase, encapsulation efficiency, and kinetics of formation. In order to further explore the relationship between particle size, enzymatic activity, and biomaterial's specific activity, Horseredish Peroxidase (HRP) was used to synthesise HRP@ZIF biocomposites. This study underscores the pivotal function of synthesis parameters in the production of uniform crystals with customised biocatalytic properties, providing significant insights for the design of enzyme@ZIF systems for targeted bio-applications.

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Optimized LPE Spin-Coating Strategy for the Fabrication of Oriented Pillared-Layer MOF Thin Films

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Thin-film metal–organic frameworks (MOFs) have emerged as promising candidates for advanced applications ranging from gas adsorption and separation to electronic devices and bio-related technologies. Their practical implementation, however, requires synthetic methods that are fast, reproducible, and capable of precisely controlling thickness, crystallographic orientation, and surface uniformity—critical parameters for advancing MOF thin films beyond structural novelty toward truly application-ready materials. Similar to the spin-coating protocol proposed by Chernikova and co-workers [1], we have further adapted the liquid-phase epitaxy (LPE) spin-coating method for the more structurally flexible pillared-layered MOFs bearing two types of linker molecules, introducing even greater structural diversity. In this approach metal and ligand precursor solutions are sequentially deposited on a spinning substrate with an intermediate washing step constituting a single growth cycle (Figure 1a). As a model system, a pillared-layer framework Zn_2BDC_2DABCO (BDC = terephthalate, DABCO = 1,4-diazabicyclo[2.2.2]octane) was deposited onto a self-assembled monolayer (SAM) of 16-mercaptohexadecanoic acid (MHDA) or (4-(4-pyridyl)phenyl)methanethiol (PP1) to develop an automated fabrication protocol with the systematic quality control after each step achieving full reproducibility (Figure 1b).

Key optimized synthetic parameters include reagent concentrations, solution volume per cycle, drop flow rate, and, notably, ligand-to-ligand molar ratio. Adjusting the molar ratio enables control over the preferential orientation of the MOF thin film, allowing the selective formation of out-of-plane orientation—an outcome not achievable with other synthesis methods [2]. The developed LPE spin-coating strategy is fast and resource-efficient (small chemical consumption, quick, ambient conditions) offering a general route for the fabrication of 3D MOF films and enabling precise structural engineering for advanced functional applications.

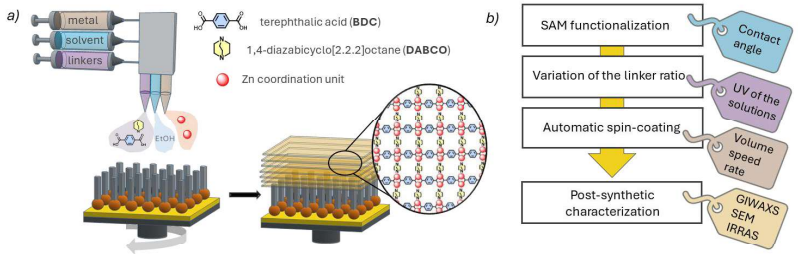

Figure 1. a) Schematic representation of the LPE spin-coating technique; b) step-by-step synthetic protocol.

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Electrostatic Design of Porous Materials

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Collective electrostatic effects significantly impact the electronic structures of hybrid interfaces and surfaces.[1] They arise from the superposition of electrostatic potentials of periodically arranged (di)polar entities and have severely impacted our understanding of surfaces. In this contribution, I will discuss, how collective electrostatics could be used outside the beaten paths of materials design for realizing systems with advanced and sometimes unprecedented properties.[2] The idea of aligning dipoles at interfaces has been extensively explored for tuning injection properties at electrodes, changing contact resistances in organic transistors by up to three orders of magnitude.[3] Of particular interest in the present context is how electrostatic design could be exploited in metal-organic and covalent-organic frameworks (MOFs and COFs).

Regarding MOFs, we have explored the inclusion of polar linkers into thin films, which allows the realization of electrostatic potential gradients within MOF structures.[4],[5] The not fully resolved challenge here is how to achieve an alignment of polar apical linkers in pillar-layer MOFs in a non-centrosymmetric fashion.[5] In contrast, COF-structures with polar groups decorating pore walls are rather common, even though the collective electrostatic effects resulting from the periodic alignments of polar groups have been largely overlooked. This can be problematic, when interpreting experimental results dealing with catalysis, battery application and excited-state charge-transfer processes. This is a consequence of the fact that polar substituents at pore walls can shift the electrostatic energy within the pores by clearly more than one eV.[6] This has severe consequences for the relative alignment of electronic states in the COFs and in guest molecules contained in the pores. [6],[7] The electrostatically induced shifts are relatively insensitive to local defects and COF stacking faults, Moreover, they can be selectively tuned by post-synthetic modification reactions.[7] This opens up the possibility of realizing potential pockets or potential gradients within the pores,[7] which could eventually be used for localizing ionic guest molecules or for driving them into specific directions.

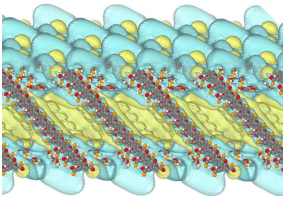

Figure 1: Electrostatic energy pockets in a COF thin film with regularly arranged polar substituents decorating the pore walls. The outermost three layers on each side are assumed to be post-synthetically modified. For more details see Ref. [7]. The yellow isosurface corresponds to an energy increase by 0.4 eV and the blue isosurface to an energy decrease by 0.1 eV relative to the electrostatic energy above the COF layer.

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Solvent-free thermal defect engineering in metal-organic frameworks to generate accessible open metal sites

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The controlled generation of defects in crystalline materials is widely used to tune properties for improved performance. This strategy is increasingly applied to metal-organic frameworks (MOFs), where coordination vacancies are commonly introduced in solution by exploiting the reversibility of metal–ligand bonds.[1] We present an innovative solvent-free approach for defect engineering in MOFs based on the selective thermal removal of neutral volatile linkers.[2] This method enables the generation of metal vacancies across a broad compositional space (0-100%) without requiring counterions, redox adjustments, or oxide formation to balance charge. Using a standard thermogravimetric analyser, we control the extent of linker sublimation with high precision and reproducibility. We identify key design criteria for applying this strategy and validate it with the Hofmann-type MOF $[Fe(pz)\{Pt(CN)_4\}]$ (pz = pyrazine).[3] Structural and spectroscopic analyses reveal a local transformation from FeN_6 to FeN_4 environments, leading to redox-stable unsaturated Fe^{II} sites. These open centres remain chemically accessible and can hence catalyse Lewis acid-type reactions. The ability to generate open metal sites without solvents or charge-balancing agents offers an alternative route for applications that require a precise control of defects, including the binding molecules of biological interest.[4]

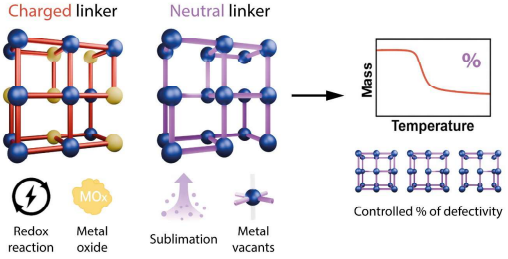

Figure 1. Innovative nature of the solvent-free thermal MOF defect engineering with neutral volatile linkers instead of charged ones.

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New Electroneutral Polymers Forming Lipid-Bilayer Nanodiscs for the Study of Membrane Proteins

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Polymer-encapsulated nanodiscs provide a well-controlled and dynamic lipid-bilayer environment for the study of membrane proteins under native-like conditions [1,2]. However, a major limitation of established nanodisc-forming polymers is their high charge density, which interferes with native biomolecular interactions and some analytical techniques. Therefore, our group focuses on developing new, electroneutral nanodisc-forming polymers [1]. Here, we present Carboxy-DIBMA, a zwitterionic copolymer that outperforms established, charged nanodisc-forming polymers in the following aspects. First, Carboxy-DIBMA nanodiscs remain stable over a wide range of pH values and mono- and divalent ion concentrations. Second, the charge of Carboxy-DIBMA nanodiscs is determined solely by the charge of the encapsulated lipids. Third, Carboxy-DIBMA nanodiscs preserve a native-like lipid-bilayer structure. Finally, the rapid lipid exchange among Carboxy-DIBMA nanodiscs is unaffected by the presence of ions, highlighting the electroneutrality of the polymer and the dynamic nature of this novel membrane mimetic. In conclusion, Carboxy-DIBMA nanodiscs offer new opportunities to study membrane proteins in a native-like lipid-bilayer environment without charge interference.

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P9

Free-Radical Polymerisation within Nanostructured Inverse Cubic and Hexagonal Architectures

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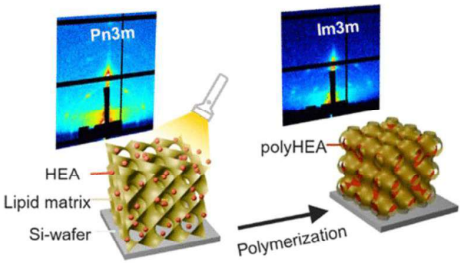

Lipid-based liquid crystalline mesophases are considered building blocks for biological membranes.[1] Their structural complexity can be utilized to compartmentalize molecules and provide an opportunity to study diffusion-controlled reactions, such as free radical polymerization within nanodomains or at the liquid-liquid interface.[2] In this study, we investigate the impact of monomer integration and photopolymerization within inverse bicontinuous cubic (Pn3m) and inverse hexagonal (H_2) thin films. Acrylate monomers of different polarity were integrated into the structured films and photopolymerized using a hydrophilic photoinitiator. In situ grazing-incidence small-angle X-ray and neutron scattering (GISAXS and GISANS) experiments were conducted under water to investigate the impact of polymerization on the nanostructural transformation. Contrast matching and chemical deuteration were employed to map individual molecules within multi-domain structures. The results were complemented with NMR and GPC analysis.The findings provide an advanced understanding of the role of compartmentalization in the initialization and mechanisms of diffusion-controlled free radical reactions at liquid-liquid interfaces. It may guide the development of novel nanostructured materials.

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P10

Nanoscale Ga-MOFs as Synergistic Drug-Delivery Platforms for Anticancer Therapy

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Gallium (Ga) possesses intrinsic anticancer and antibacterial properties by disrupting iron metabolism, however, its low bioavailability, short half-life, and poor tumour-targeting capacity limit effective delivery [1-2]. Metal-organic frameworks (MOFs), known for their high storage capacities, tuneable structures, functionalisability, and biodegradability, are promising nanoscale drug delivery systems (DDSs) [3]. Yet, most MOFs are biologically inert and offer minimal therapeutic benefits. Incorporating Ga into MOFs (Ga-MOFs) provides a dual advantage, serving as both the carrier and an active therapeutic agent by disrupting ion homeostasis in tumour cells. Despite the potential, the biological applications of Ga-MOFs, especially for anticancer therapy, remain largely unexplored.

This study reports the synthesis of four nano-Ga-MOFs (MIL-53, MIL-100, NH_2-MIL-88, and NO_2-MIL-101) for anticancer applications, aiming to enhance efficacy through synergistic combination with chemotherapeutics. Conventional methods typically yield micron-sized Ga-MOFs unsuitable for drug delivery. In contrast, our approach produced particles <100 nm. Among the candidates, MIL-53(Ga) and MIL-100(Ga) demonstrated the highest stability and uniformity, with MIL-100(Ga) selected for further study due to superior biocompatibility and lower toxicity.

To improve stability and sustain drug release, MIL-100(Ga) was surface-modified with mPEG─PO_3 (M_n=2000). Doxorubicin (DOX)-loaded MIL-100(Ga) was prepared to achieve a synergistic effect and reduce the required therapeutic dose. PXRD, TGA, and IR spectroscopy confirmed successful PEGylation and DOX encapsulation, achieving a 7 wt % loading after PEGylation. SEM analysis showed that the uniform spherical morphology was preserved throughout the drug loading and polymer coating. In vitro assays in HepG2 cells demonstrated enhanced anticancer activity after 24 h compared to individual treatments.

Oxaplatin (OXA)-loaded MIL-100(Ga) was also investigated, achieving 4 wt % loading as determined by ICP analysis. SEM confirmed morphological integrity post-loading, and cytotoxicity assays revealed significant synergistic antitumour effects in HepG2 cells after 48 h. Due to the low OXA loading, IR and TGA analyses provided no clear evidence of drug presence.

Ongoing work will evaluate the stability of Ga-MOF in PBS, drug-release kinetics, cellular uptake, 3D cell culture experiments, and in vivo therapeutic efficacy. These findings establish MIL-100(Ga) as a promising multifunctional platform for combined gallium- and drug-based cancer therapy.

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P11

Light-Driven Hybrid Nanoreactor Harnessing the Synergy of Carboxysomes and Organic Frameworks for Efficient H_2 Production

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Abstract body: Synthetic photobiocatalysts are promising catalysts for valuable chemical transformations by harnessing solar energy inspired by natural photosynthesis.[1, 2] However, the synergistic integration of all of the components for efficient light harvesting, cascade electron transfer, and efficient biocatalytic reactions presents a formidable challenge.[3-5] In particular, replicating intricate multiscale hierarchical assembly and functional segregation involved in natural photosystems, such as photosystems I and II, remains particularly demanding within artificial structures. Here, we report the bottom-up construction of a visible-light-driven chemical-biological hybrid nanoreactor with augmented photocatalytic efficiency by anchoring an α-carboxysome shell encasing [FeFe]-hydrogenases (H-S) on the surface of a hydrogen-bonded organic molecular crystal, a microporous α-polymorph of 1,3,6,8-tetra(4'-carboxyphenyl)pyrene (TBAP-α). The self-association of this chemical-biological hybrid system is facilitated by hydrogen bonds, as revealed by molecular dynamics simulations. Within this hybrid photobiocatalyst, TBAP-α functions as an antenna for visible-light absorption and exciton generation, supplying electrons for sacrificial hydrogen production by H–S in aqueous solutions. This coordination allows the hybrid nanoreactor, H–S|TBAP-α, to execute hydrogen evolution exclusively driven by light irradiation with a rate comparable to that of photocatalyst-loaded precious cocatalyst. The established approach to constructing new light-driven biocatalysts combines the synergistic power of biological nanotechnology with the multilength-scale structure and functional control offered by supramolecular organic semiconductors. It opens up innovative opportunities for the fabrication of biomimetic nanoreactors for sustainable fuel production and enzymatic reactions.

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P12

The Synthesis of Aluminium Metal-Organic Frameworks and their Potential as Vaccine Adjuvants

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Metal-organic frameworks (MOFs) have been one of the fastest growing areas of chemistry within the past 20-30 years. An interplay of the porosity and high level of tunability of these structures has resulted in promising efficacy in potential applications, namely in areas such as gas storage, catalysis, and drug delivery. However, the synthesis of these materials, while seemingly simple, is a complex, multifaceted process. Due to this, researchers must design experiments based on limited knowledge of a formation mechanism, and as such many rely on high-throughput experiments and large reaction-optimisation trials to fine tune the synthetic parameters required for their desired properties. Aluminium MOFs show huge promise in many applications due to their high stability and low production costs. In recent years, there have been efforts to harness various features of metal-organic frameworks for use as vaccine adjuvants. These efforts have involved the use of Al-MOFs as dual-purpose vaccine adjuvant and carriers [1], [2], and more conventional adjuvant only formulations [3].

Herein, we display some preliminary results from our own study into the selective activation of dendritic cell costimulatory markers for potential use as vaccine adjuvants. Several MOFs were tested against mouse derived bone marrow dendritic cells, and it was found that in addition to the linker length having an effect on the intensity of co-stimulatory marker expression as in Stillman *et al* [3], changing the metal within the SBU (secondary building unit) can selectively activate different co-stimulatory markers to varying extents. A study was also completed on the effect of various linkers with an aim of identifying how specific chemical features effect the surface protein response of the dendritic cells.

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P13

Biohybrid Colorimetric Tattoo Sensor for Real-Time Sweat pH-Monitoring and Dynamic Sweat Management

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Temporary tattoo-based sensors are redefining wearable diagnostics by enabling real-time monitoring of sweat biomarkers using electronics-free, ultra-conformal platforms. Their skin-like adhesion, minimal invasiveness, and direct interface with sweat glands make them ideal for continuous, on-body biosensing.

We present a colorimetric tattoo sensor for real-time sweat pH-monitoring, built on a porous substrate functionalized with a pH-sensitive indicator dye. The ultra-thin tattoo conforms seamlessly to the skin's complex microtopography and produces a visible, reversible color change within the physiologically relevant pH range of 4 – 6, providing immediate feedback on hydration level and physiological stress. A precisely engineered 6 µm transfer layer ensures uniform thickness, structural integrity, and reproducible sensor performance. Crucially, the tattoo's excellent water vapor permeability supports sweat detection across a wide range of perspiration levels – ensuring stable performance under dynamic physiological conditions.

A key innovation of the tattoo sensor is its biohybrid interface, where the porous matrix enables both efficient analyte diffusion and vapor transport. The functionalized tattoo exhibits a water vapor permeability of 255 g*mm/m^2*d*atm, allowing for passive sweat evaporation even under moderate physical activity. This continuous evaporation prevents biomarker dilution and ensures a steady refresh of sweat – critical for achieving high temporal resolution. With a vapor transport rate of 0.47 L/h*m^2, the tattoo operates within the physiological range spanning from the low sweat rates of sedentary individuals to the peak rates observed during intense exercise [1,2].

This work exemplifies the fusion of porous material engineering, biocompatibility, and smart sweat management in a soft, wearable format – paving the way for next-generation, multi-analyte tattoo sensors for personalized health monitoring.

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P14

Post-synthetic immobilization of enzymes into ZIF-8 preserves stability and activity.

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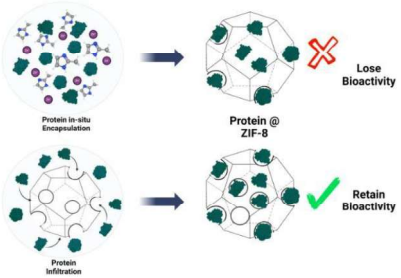
Enzymes are biological catalysts that accelerate chemical reactions in living organisms, playing a crucial role in various physiological processes. Targeted delivery of enzymes is a promising area of research for treating various diseases; however, their intrinsic fragility, which includes low heat stability, limited pH tolerance, and susceptibility to denaturants in organic solvents, remains an issue. Encapsulation of biomacromolecules in metal–organic frameworks (MOFs) can preserve biological functionality in harsh environments, but this often leads to compromised enzyme activity. Here, we demonstrate that employing enzyme infiltration instead of one-pot encapsulation within zeolitic imidazolate framework-8 (ZIF-8) preserves the catalytic potential of the enzyme. Our data showed that for the three different enzymes we tested that the in-situ encapsulating process by ZIF-8 resulted in the inactivation of enzymes due to their fragile nature, and that the ZIF-8 precursor caused conformational changes to the protein, which cause denaturation. In addition, according to our results, minimizing the interaction between ZIF-8 and the enzymes through infiltration did not alter the enzyme activity. The proposed strategy employs milder conditions, which can preserve the biofunctionality and the catalytic activity of enzymes.



BBPore 2025 Graz Connect Poster Abstract

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University of Vienna

Combination chemotherapy is widely employed in advanced cancer therapy, offering superior outcomes compared to single-drug treatments. A major challenge, however, lies in realizing the precise temporal control of multiple drug releases using a single delivery system without introducing excessive complexity. In this work, we present injectable nanocomposites composed of nanoscale metal–organic frameworks (MOFs) and thermoresponsive hydrogels as a flexible platform for localized and differential drug administration. Four clinically used chemotherapeutics—gemcitabine (GEM), 5-fluorouracil (5-FU), doxorubicin (DOX), and paclitaxel (PTX) - were studied in terms of encapsulation, host-guest interactions, and *in vitro* release behavior. By exploiting their distinct release profiles from MOFs and the bulk gel phase, we engineered dual and triple drug formulations capable of sustained release for 10-18 days with clinically relevant dosing sequences. The composites remained highly injectable below body temperature, enabling minimally invasive delivery directly to tumor sites. Overall, this strategy demonstrates the potential of MOF–thermogel systems as customizable carriers for tunable multidrug release kinetics and sequencing in solid tumor chemotherapy.

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Metal-organic frameworks (MOFs) responsive colorimetric sensor for real-time monitoring of food quality

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Abstract

Biogenic amines are important indicators of food spoilage, produced when protein-rich foods such as meat, eggs, and dairy products deteriorate[1]. Monitoring their presence in real time is crucial for ensuring food safety. Traditional detection methods, however, are often complex, expensive, and unsuitable for on-site applications.

The FRESCO (Food Responsive Sensor for Colorimetric Observation) project addresses this challenge by integrating metal-organic frameworks (MOFs) into flexible packaging materials. MOFs are crystalline porous materials composed of metal clusters connected by organic ligands[2], and their high porosity allows them to interact efficiently with guest molecules[3][5]. In FRESCO, MOFs containing porphyrin groups undergo distinct color changes when adsorbing biogenic amines, enabling continuous visual monitoring of food quality[6] This proton-triggered colorimetric response of porphyrin MOFs is highly reversible and extremely sensitive[7], allowing rapid responses within a very short time and producing clear and observable color changes.

This intelligent, low-cost colorimetric sensor exhibits rapid responses under simulated spoilage conditions and can be incorporated into packaging materials. It can also be combined with smartphone applications for more precise monitoring. By enabling real-time detection of specific volatile compounds, FRESCO advances the development of smart, responsive food packaging technologies.

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P17

Engineered Porous Nanocellulose–Collagen Hydrogels for Biomedical Applications in 3D In Vitro Neuronal Models

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Understanding neurodegenerative diseases requires advanced in vitro models capable of sustaining neuronal viability and morphology over extended periods. SH-SY5Y neuroblastoma cells are widely used for modeling neurodegeneration, but traditional 2D cultures lack the spatial and biochemical complexity of native tissue. Although 3D cultures offer improved physiological relevance, most systems tested with SH-SY5Y cells are limited to short-term applications. In this study, we developed nanocellulose-based hydrogels blended with small amounts of type I collagen to create a tunable 3D matrix capable of supporting neuronal cultures for at least 14 days. Cellulose nanofibers were chemically modified via TEMPO-mediated oxidation (TNC) or a combined TEMPO-periodate treatment (PTNC) to enhance hydrophilicity and improve fiber dispersion. These engineered hydrogels provide a biocompatible environment suitable for the 3D culture of SH-SY5Y neuroblastoma cells. The resulting composites show distinct structural properties: PTNC–collagen gels are transparent and more homogeneous, while TNC samples contain a broader range of fiber sizes. AFM and SHG analyses revealed uniform collagen fibrillation only in PTNC-based gels with a minimum of 0.5 mg/mL collagen. By varying cellulose and collagen concentrations, we tuned the mechanical properties across a range suitable for neuronal cultures (4–100 Pa). SH-SY5Y cells embedded in these hydrogels showed high viability (>90%) after 14 days, with PTNC–collagen composites outperforming collagen [1] and Matrigel [2] in promoting neurite outgrowth and reducing cell clustering. These outcomes are attributed to the high surface charge and superior dispersion of PTNC fibers, which facilitate cell–matrix interactions and matrix remodeling. These findings, along with the high availability and easy processability of PTNC cellulose, highlight the potential of cellulose, when combined with small amounts of collagen, as a viable alternative to conventional animal-derived biomaterials. These cellulose-collagen gels hold promise for advancing 3D neural model development in both neurobiology and tissue engineering applications. [3].

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Germanium-based IniSwitches: Towards New Photoresponsive Materials

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Radical polymerization reactions can be induced with light by employing a photoinitiator. Acylgermanes have been established as efficient photoinitators across a wide range of wavelengths [1]. Recently it has been demonstrated that acylgermanes can be conjugated onto surfaces, anchoring the growing polymer chain and enabling facile access to functionalized surfaces [2]. Molecular photoswitches are compounds that can be "switched" between different states depending on the wavelength of illumination. One such molecule is azobenzene, which can be reversibly photoisomerized between its *cis* and *trans* isomer. Conjugating azobenzene to polymers gives access to materials that can undergo reversible phase changes when illuminated at different wavelengths, which has potential applications in the field of energy storage [3].

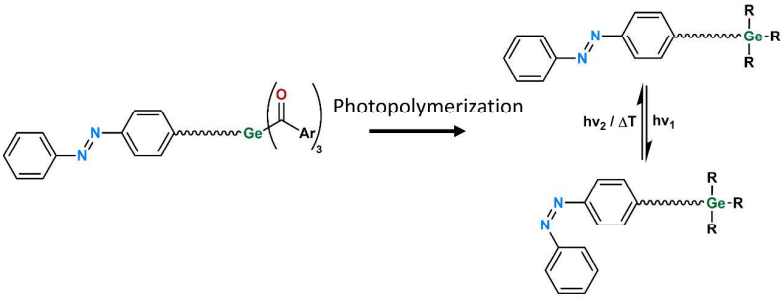

Figure 1. IniSwitches combine photoinitiators and molecular photoswitches in one molecule

In this study we present the first investigations on acylgermane-based IniSwitches; compounds that combine a photoinitiating acylgermane moiety and a photoswitching azobenzene moiety. We show possible synthetic pathways, investigate photochemical behavior and explore how this novel class of compounds gives access to photoswitchable polymer materials.

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Post-synthetic modification as a strategy to control properties of spherulitic JUK-74 metal-organic framework

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Metal-organic frameworks (MOFs) represent a significant class of crystalline porous materials, distinguished by their high surface area, tunable pore sizes, and highly adaptable architectures. Due to these properties, MOFs play an important role in catalysis, gas storage and separation, energy storage, sensing and drug delivery. A widely adopted approach for tailoring the properties of MOFs is post-synthetic modification (PSM), which provides a versatile route to introduce new functionalities into pre-formed frameworks by selectively targeting either the metal clusters or the organic linkers. It is particularly useful when particular structural features cannot be introduced to the structure during *de novo* synthesis.

This presentation discusses a novel tetrazine-based material, JUK-74,[1] which forms spherulitic superstructures,[2] detailing its synthesis, structure and functionalization through post-synthetic modification using the inverse electron-demand Diels-Alder (iEDDA) reaction.[3] This strategy enables the incorporation of diverse functional groups, such as hydrophobic alkyl chains, carboxyl (-COOH), and amine (-NH2) groups, even simultaneously, without disrupting the MOF's crystalline structure or its superstructure.

By demonstrating that JUK-74 can undergo such versatile functionalization while retaining both structural and morphological order, this work provides new insights into how MOF superstructures can be engineered at multiple levels of organization. The ability to combine superstructure formation with controlled chemical modification opens new pathways for the rational design of advanced materials with tailored properties.

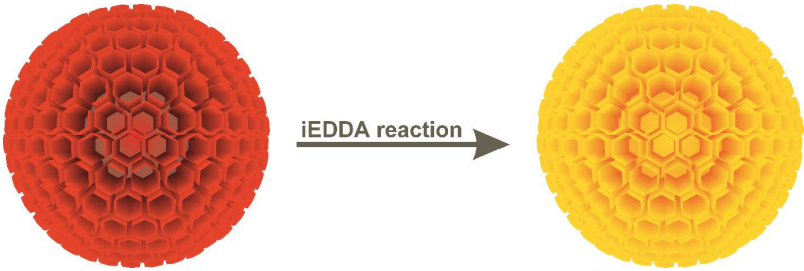

Figure 1. Scheme of the iEDDA reaction performed on a JUK-74 spherulite.

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Porous Polymers as a Platform for Heterogeneous Catalysis

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Porous polymer materials serve as highly effective and versatile matrices for the incorporation and stabilization of catalytically active species. These polymers offer several advantages: they can be synthesized from a diverse range of monomers and with varying pore sizes, providing significant flexibility to customize functionality. Furthermore, they can be prepared using a photochemical approach, which allows for spatial and temporal control while eliminating the need for hazardous reactants and time-consuming multi-step procedures.

We present selected examples of the photochemical preparation of polymers with embedded catalytic species, highlighting their potential as candidates for heterogeneous catalysis. First, we describe a facile photochemical method for the one-step synthesis of well-defined metal-polymer nanocomposites. This approach utilizes Norrish Type I photoinitiators, which, upon light irradiation, undergo bond cleavage to produce two radicals, enabling simultaneous radical polymerization and metal reduction (Figure 1). Additionally, we demonstrate post-modification of polystyrene for the preparation of a catalyst for efficient solvent-free tetrazole synthesis.[1,2]

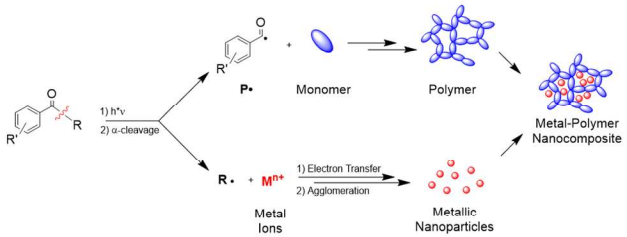

Figure 1. Photochemical One-Step Synthesis of Metal Polymer Nanocomposites

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