GLOW2026

GLObal Conference for Women Leaders and Emerging Researchers in Materials Science

GLObal Conference for Women Leaders and Emerging Researchers in Materials Science, held in Nanyang Technological University, Singapore from 29 September to 1 October 2026, is a platform to shine a spotlight on the remarkable contributions of women talents in the field of Materials Science.

Participants will explore the latest advancements and emerging trends in materials science, spanning:

- Computational Methods, Characterisation & Machine Learning
- Future Electronics & Nanomaterials
- Healthcare
- Sustainability & Energy Materials

We have also lined up poster sessions and networking opportunities for researchers to showcase their research and participants to form meaningful connections within the field. Hope your participation at GLOW 2026 offers you new insights and opportunities in your Science and Engineering journey.

Tuesday, 29 September 2026

Day 1:

0800 - 0910	Registration
0910 - 0920	Welcome Speech *Professor Lee Pooi See* *Chair, GLOW2026 Committee* *Nanyang Technological University, Singapore*
0920 - 0950	Plenary *Professor Shirley Meng* *Vice President (Industry)* *Nanyang Technological University, Singapore*
SUSTAINABILITY & ENERGY	
0950 - 1020	Keynote From Waste to Value: Materials, Devices, and Products for a Sustainable Future *Professor Francesca Toma* *Helmholtz-Zentrum Hereon, Germany*
1020 - 1040	Rapid and Sustainable Strategy for Lithium-Ion Battery Recycling and Upcycling *Dr Helena Yuan Wang* *The University of Melbourne, Australia*
1040 - 1110	Tea break
1110 – 1130	From Indoor PV Promise to Defect-Bound Hot Polarons in BiSBr *Dr Xiaoyu Guo* *University of Oxford, United Kingdom*
1130 – 1150	Protein-Based Soft Materials from Agricultural Byproducts for Resilient Food and Agricultural Systems *Assistant Professor Jiahan Zou* *Montana State University, USA*
1150 - 1210	Molecular Dynamics Investigation of Water Interfacial Behavior on Defective Hexagonal Boron Nitride (hBN) Surfaces *Dr Warin Rangubpit* *Rutgers University, USA*
1210 - 1430	Networking Lunch & Poster Session (*Poster Award Judging*)

COMPUTATIONAL, CHARACTERISATION & MACHINE LEARNING	
1430 - 1500	Keynote How Computational Methods Enable Soft Materials Innovation *Professor Arthi Jayaraman* *University of Delaware, USA & IBM Consulting, France*
1500 - 1520	From CALPHAD Screening to Two Laser Routes - *Design & Additive Manufacturing of BCC* $Nb_{25}Ti_{20}Zr_{55}$ *Julia Chmielewska* *Empa, Swiss Federal Laboratories for Materials Science and Technology, Switzerland*
1520 - 1540	Revealing Atomic-scale Dynamics in Materials and Devices via In-situ TEM *Dr Hwanhui Yun* *Korea Research Institute of Chemical Technology, South Korea*
1540 - 1600	Bio-Inspired Synergistic Design for Balancing Energy Dissipation and Electromagnetic Interference Shielding *Ailin Chen* *University of California, Berkeley, USA*
1600 - 1620	New Method to Characterize Automotive Sheet Metals in Tension and Compression during In-Plane Bending *Assistant Professor Jacqueline Node* *University of British Columbia, Canada*
1620 - 1650	Tea break

Wednesday, 30 September 2026

Day 2:

FUTURE ELECTRONICS / NANOMATERIALS	
0900 - 0930	Keynote Designer Materials and Devices – Building Extraordinary Structures and Functions with Colloidal Nanocrystals *Professor Cherie R Kagan* *University of Pennsylvania, USA*
0930 - 0950	Optimization of Organic Photodetecting Devices Towards Infrared Applications *Assistant Professor Chiara Labanti* *National Taiwan University, Taiwan*
0950 - 1010	Unravelling the Role of Polyelectrolyte Brushes in Synaptic Devices *Esli Diepenbroek* *University of Twente, Netherlands*
1010 - 1040	Tea break
1040 - 1100	Development of Novel Multi-Element Metal Sulfide Nanosheets *Assistant Professor Megumi Mukoyoshi* *Kyoto University, Japan*
1100 - 1120	Modular, Thermally Driven Asymmetric Micro-Actuators for Untethered Soft Robotic Locomotion *Dr Jacqueline Figueiredo da Silva* *Johannes Gutenberg-Universität Mainz, Germany*
1120 - 1150	Keynote Cool Plastics for Novel Electronics and Photonics *Professor Natalie Stingelin* *Georgia Institute of Technology, USA*
1150 - 14.00	Networking Lunch & Poster Session (*Poster Award Judging)*
1400 - 1500	PANEL DISCUSSION: Innovation in the Age of AI Facilitator: *Professor Ling Xing Yi, Nanyang Technological University, Singapore* Panellists: *Professor Cherie Kagan, University of Pennsylvania, USA* *Professor Arthi Jayaraman, University of Delaware (UD), USA & IBM Consulting, France* *Prakash Rau, Director (NAND Process Integration), Micron Technology*
1500 - 1520	Publishing in the Era of AI *Professor Jessica Winter* *Editor-in-Chief, Journal of Materials Chemistry B (RSC)* *Ohio State University*
1520 - 1535	NTU Emerging Scientists Session

	Quasi-2D Lead-Free Halide Double Perovskite-Based Piezoelectric Bimodal Tactile Sensor for Soft Robotic Gripper *Jiamin Amanda Ong*
1535 - 1550	t_2 Occupancy as a Descriptor for Polysulfide Conversion on Spinel Oxides *Xie Wen*
1550 - 1620	Tea break

Thursday, 1 October 2026

Day 3:

HEALTHCARE	
0900 - 0930	Keynote From What If to Clinical Trials: Designing Materials to Solve Problems in Medicine *Professor Molly Shoichet* *University of Toronto, Canada*
0930 - 0950	Self-propelled Pectin Micromotors for Enhanced Penetration and Drug Delivery to In-vitro Breast Cancer Cells *Assistant Professor Swathi Sudhakar* *Indian Institute of Technology Madras, India*
0950 - 1010	Bio-based Materials for Continuous Monitoring of *E. coli* in Urinary Catheters: TimeUp Device *Dr Marta Santos* *University of Coimbra, Portugal*
1010 - 1040	Tea break
1040 - 1100	Mg–Na Doped HA 3D-Printed Scaffolds Enhance Bone Regeneration in Critical-Sized Defects *Dr Maria Apriliani Gani* *Bandung Institute of Technology, Indonesia*
1100 - 1130	Keynote Dynamic Materials for Biofabrication of Personalized Tissue Mimics *Professor Sarah Heilshorn* *Stanford University, USA*
1130 - 1200	Travel & Poster Award Presentation Closing Remarks *Professor Ng Kee Woei* *Chair, GLOW2026 Committee* *Nanyang Technological University, Singapore*
1210 - 1330	Networking Lunch
1330 - 1500	Campus & Lab Tour

KEYNOTES

SUSTAINABLITY & ENERGY
Professor Francesca Toma
Helmut Schmidt University, Germany

Prof. Francesca M. Toma is the Director of the Institute of Functional Materials for Sustainability at Helmholtz-Zentrum Hereon & a Distinguished Helmholtz Professor at Helmut Schmidt University Hamburg, Germany. Her research centers on the synthesis & characterization of sustainable materials for renewable energy & biological applications. She also holds a position as a Visiting Professor at Lawrence Berkeley National Laboratory. She earned her Ph.D. in Biophysics from the International School of Advanced Studies in Italy in 2009 & gained postdoctoral experience at the University of Trieste before moving to the University of California, Santa Barbara, as a Marie Curie Researcher in 2011, & then to the University of California, Berkeley in 2013. For nearly a decade, she served as a Staff Scientist at Lawrence Berkeley National Laboratory, where she was the Program Lead of the Liquid Sunlight Alliance & the Photoelectrochemistry Technology Lead for HydroGEN. In 2022, she also served for a year as a Detailee in the Catalysis Science Program of Basic Energy Sciences at the U.S. Department of Energy. Prof. Toma has co-authored more than 120 publications, focusing on (photo)electrocatalysis, drug delivery, & tissue engineering. Her work has garnered international recognition with several awards. She was honored as one of the "100 Women of Materials Science" by the Royal Society of Chemistry in 2018 & received the "Rising Star" Award from the American Chemical Society in 2021. She was also awarded the “Alfredo di Braccio Award” by the Italian Academy of Science. In 2022, she was selected as an Oppenheimer Fellow by the U.S. National Laboratory Directors' Council, underscoring her contributions as a leader advancing scientific research. The Division of Energy & Fuels of the American Chemical Society selected her as a finalist for the 2025 Energy Lectureship in the Mid-Career category. She serves on the Editorial Advisory Board of *ACS Catalysis* & the Editorial Board of *SustEnergMat*. She is also an Associate Editor of three journals, including *npj Materials Sustainability*, *Progress in Materials Science*, & *EES Solar*.

From Waste to Value: Materials, Devices, and Products for a Sustainable Future

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Abstract

A sustainable energy and materials future depends not only on discovering new functional materials, but also on rethinking the resources, processes, and life cycles that surround them. Rather than treating sustainability as an afterthought applied to existing production routes, we pursue an approach in which circularity, resource efficiency, and reduced environmental impact are built into materials design from the outset.

This talk presents this approach through a set of illustrative directions from our work. We discuss the valorisation of biomass derived byproducts, such as lignin, as a feedstock for functional materials rather than as waste, and we show how such underused resources can be transformed into high performance materials, devices, and products through careful control of their chemistry and processing. We further discuss fermentation based routes to chemical production, in which biological processes replace energy intensive chemical synthesis, offering pathways toward chemicals and materials with substantially lower environmental footprints. Alongside these biological and biomass based routes, we consider electrochemical and photoelectrochemical approaches that use renewable

electricity or sunlight to drive the conversion of simple feedstocks into valuable chemicals and fuels, providing a complementary route toward waste reduction and resource efficiency. Across these examples, a common thread emerges, namely that sustainability and performance need not be competing objectives, and that materials designed with circularity in mind can meet or exceed the standards set by conventional approaches.

Beyond the specific material systems, this talk reflects on what these directions suggest about the broader design principles needed to advance solutions that are both scientifically rigorous and genuinely sustainable.

COMPUTATIONAL, CHARACTERISATION & MACHINE LEARNING

Professor Arthi Jayaraman
University of Delaware, USA & IBM Consulting, France

Dr. Arthi Jayaraman is an accomplished leader in computational materials science & chemical engineering, currently serving as the Chief Scientist for AI for Materials at IBM Consulting in France. Her career includes long-standing tenure at the University of Delaware as a Full Professor & the Centennial Term Professor for Excellence in Research & Teaching. Throughout her academic career, she has led the development & use of molecular modeling, simulations, & machine learning workflows, such as CREASE & RAPSIDY, to accelerate the discovery & characterization of complex soft materials. As of June 2026, Dr. Jayaraman has authored over 135 peer-reviewed publications & delivered more than 250 invited lectures globally. Her leadership extends to significant editorial roles, including serving as an Associate Editor for Macromolecules & the inaugural Deputy Editor of ACS Polymers Au. She is a Fellow of the American Physical Society, the American Chemical Society (PMSE), & the Royal Society of Chemistry & has received several honors including the IMPACT award from AIChE (American Insitute of Chemical Engineers) COMSEF Division, BITSAA Distinguished Alumna Award, & US-Department of Energy (DoE) Early Career Award. Furthermore, she has a proven track record of bridging the gap between academia & industry, having directed major NSF-funded initiatives & collaborated with global leaders such as Dow, DuPont, Merck, Chemours, IFF, Arkema, W.L. Gore & 3M. Her experiences seamlessly integrate polymer physics & chemistry with state-of-the-art computations making her a leading authority in the area of digital materials discovery & innovation.

How Computational Methods Enable Soft Materials Innovation

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Abstract

In this talk, I will highlight how advances in molecular modeling, simulation, and machine learning are transforming the design and discovery of soft materials and polymer systems. By integrating coarse-grained and atomistic simulations with data-driven approaches, researchers can uncover molecular-level structure–property relationships that govern material behaviors across multiple length and time scales. The presentation will showcase strategies for leveraging machine learning to accelerate exploration of vast polymer design spaces while preserving the physical insights afforded by traditional computational methods. I will present examples that demonstrate how these combined approaches enable prediction of self-assembly, dynamics, transport, and mechanical properties in complex soft matter systems. I will conclude my talk with some perspectives on the future of AI-enabled polymer science and the opportunities created by integrating computation, data, and materials innovation.

FUTURE ELECTRONICS / NANOMATERIALS
Professor Cherie R Kagan
University of Pennsylvania, USA

Cherie R. Kagan is the Stephen J. Angello Professor of Electrical & Systems Engineering, Professor of Materials Science & Engineering, & Professor of Chemistry at the University of Pennsylvania. She is the Director of the U.S. National Science Foundation Engineering Research Center for the Internet of Things for Precision Agriculture (IoT4Ag) & served as Penn Engineering's Associate Dean for Research (2019-2024). She graduated from the University of Pennsylvania in 1991 with a BSE in Materials Science & Engineering & a BA Mathematics & earned her PhD in Materials Science & Engineering from the Massachusetts Institute of Technology in 1996. In 1996, she went to Bell Labs as a postdoctoral fellow & in 1998, she joined IBM's T. J. Watson Research Center, where she most recently managed the "Molecular Assemblies & Devices Group." In 2007, she joined the faculty of the University of Pennsylvania. The Kagan group's research is focused on studying the chemical & physical properties of nanostructured materials & in integrating materials with optical, electrical, magnetic, mechanical, & thermal properties in (multi-)functional devices. The group combines the flexibility of chemistry & bottom-up assembly with top-down fabrication techniques to create materials & devices with applications in electronics, photonics, & sensing. Kagan is a Fellow of the National Academy of Inventors, of the American Academy of Arts & Sciences, American Association for the Advancement of Science, & of the IEEE, MRS, Optica, & APS societies; she is a recipient of the Alexander von Humboldt Foundation Research Award; Penn Engineering's Heilmeier & S. Reid Warren, Jr Awards, & was the 2021 President of the Materials Research Society, & an Associate Editor of ACS Nano for 8 years.

Designer Materials and Devices – Building Extraordinary Structures and Functions with Colloidal Nanocrystals

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Abstract

There is still "plenty of room" *in the middle* between 1 nm and 100 nm, an interesting length scale commensurate with natural physical phenomena (e.g., electronic, optical, and magnetic effects) and the typical size range of colloidal nanocrystals (NCs). NCs can be exquisitely tailored in size, shape, and composition and as colloids, they can be assembled using solution-based coating, printing, and imprinting techniques into 2D and 3D materials hierarchically structured from the nano to micro scales. In this talk, I will describe our work using NCs as "artificial atoms" to build materials and devices with extraordinary structures and functions. We design materials and devices from single- and multiple-types of NCs and exploit what makes NCs different from bulk materials, notably their size and composition dependent physical properties and the ability to chemically and thermally address NCs to exchange, strip, or add surface atoms, ions, and molecules during or post-deposition. By designing NC materials with multiple functions, we demonstrate NC (opto)electronics, 2D and 3D optical metamaterials, and active matter.

FUTURE ELECTRONICS / NANOMATERIALS
Professor Natalie Stingelin
Georgia Institute of Technology, USA

Natalie Stingelin is a Full Professor at the Georgia Institute of Technology & the Chair of the School of Materials Science & Engineering. She held prior positions at Imperial College London, UK, at Queen Mary University of London, UK; the Philips Research Laboratories in Eindhoven, The Netherlands; the Cavendish Laboratories, University of Cambridge, UK; & the Swiss Federal Institute of Technology (ETH) Zürich, Switzerland. She is an Associate Editor of the Journal of the American Chemical Society (JACS), & served as the Director of Georgia Tech's Center of Organic Electronics & Photonics till 2023. She is a Fellow of the U.S. National Academy of Inventors (NAI), the European Academy of Sciences (EurASc), the American Physical Society (APS), the Materials Research Society (MRS), & the Royal Society of Chemistry (RSC). Her research interests encompass the broad area of functional polymer materials, sustainable plastics, polymer physics, organic electronics & photonics, & bioelectronics.

Cool Plastics for Novel Electronics and Photonics

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Abstract

With seabirds trapped in multipack drink rings, and mid-ocean islands of indestructible rubbish, the idea that plastics could play a big part in a sustainable future world might seem far-fetched. However, new smart plastics may yet rescue the reputation of this all-consuming 20th century material. Research into 'cool plastics' could improve the energy efficiency and performance of a range of optoelectronic devices and beyond. We will present recent efforts to design plastics of desired functions targeted for a greener world. We will discuss the potential of systems that can offer the same flexibility, softness and light weight as commodity plastics but can control the flow of light, charge carriers and heat, therefore, assisting energy and light management in light-emitting diodes in the form of heat mirrors and light in-/out-coupling structures, increase the functionality of photovoltaic applications when used as anti-reflection coatings and semi-transparent mirrors, as well as building blocks for novel optical structures that can lead to quantum devices. Ultimately, these advances point toward a new generation of functional plastics that unite performance with sustainability. By redefining what plastics can do, such materials may transform a global challenge into a key part of the solution.

Keywords: heat management, light management, energy consumption reduction, green materials

HEALTHCARE
Professor Molly Shoichet
University of Toronto, Canada

Professor Molly Shoichet is University Professor, a distinction held by less than 2% of the faculty. She is the inaugural Pamela & Paul Austin Chair in Precision & Regenerative Medicine, & Scientific Director of Precision Medicine (PRiME) & BioHubNet at the University of Toronto. Shoichet served as Ontario's first Chief Scientist in 2018 where she worked to enhance the culture of science. Dr. Shoichet has published over 850 papers, patents & abstracts & has given nearly 600 lectures worldwide. She currently leads a laboratory of 30 & has graduated 305 researchers. Her research is focused on drug & cell delivery strategies in the central nervous system (brain, spinal cord, retina), 3D hydrogel culture systems to model cancer & colloidal drug aggregates. Dr. Shoichet co-founded four spin-off companies, is actively engaged in translational research & science outreach. Dr. Shoichet is the recipient of many prestigious distinctions & the first (and until recently the only) person to be inducted into all three of Canada's National Academies of Science of the Royal Society of Canada, Engineering & Health Sciences. Professor Shoichet is an Officer of the Order of Canada & holds the Order of Ontario. Dr. Shoichet is the L'Oreal-UNESCO For Women in Science Laureate for North America, 2015, Foreign Member of the US National Academy of Engineering, Fellow of the US National Academy of Inventors, recipient of the Killam Prize in Engineering, 2017 & Fellow of the Royal Society (UK). Dr. Shoichet is the NSERC Herzberg Gold Medal awardee, 2020 (the highest award in science/engineering in Canada), recipient of the Margolese National Brain Disorders Prize, & Acta Biomaterialia Gold Medal recipient, 2026. Dr. Shoichet received her SB from the Massachusetts Institute of Technology (1987) & her PhD from the University of Massachusetts, Amherst in Polymer Science & Engineering (1992).

From What If to Clinical Trials: Designing Materials to Solve Problems in Medicine

M.S. Shoichet[1], D. Gupta[1], K. Vulic[1], M. Ip (nee Pakulska) [1], M. Cooke[1], M. Hettiaratchi[1], M. O'Meara[2], N. Letko-Khait[1], A. Baker[1], A. Forman[1], J. Labriola[1], M. Dang[1], J. Sivak[3], R. Devenyi[3], C. Morshead[1], B.K. Shoichet[2]

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Abstract

By asking a series of "what if?" questions, we have invented new materials. For example, it is difficult to deliver therapeutics to the central nervous system – brain, spinal cord, retina – because the blood brain barrier limits diffusion from the systemic circulation therein. We wondered if we could circumvent this barrier and deliver therapeutics directly to the brain and spinal cord. To answer this question, we invented a hydrogel comprised of hyaluronan and methyl cellulose (HAMC) in which we encapsulated therapeutics for local delivery. HAMC is an inverse thermogelling, shear-thinning polymer that is injectable through a fine needle [1]. AmacaThera, a spin-off company from our lab, is now advancing the HAMC hydrogel for local delivery of non-opioid pain drugs for post-surgical pain in clinical trials.

We wondered if we could deliver chondroitinase abc (ChASE) directly to the injured spinal cord. Since ChASE itself is easily degraded, we re-engineered it with 37 point mutations based on computational models and found that this new ChASE37 was more stable and bioactive than the wildtype [2]. We realized that we needed a new hydrogel to deliver

ChASE37 and invented dexime, which is a biocompatible, click-crosslinked polymer [3]. ChASE37 has been shown to be efficacious in both stroke and spinal cord injury models.

We wondered if we could design a hydrogel to serve as a vitreous substitute after retina detachment in the eye. We invented hyaluronan-oxime, which is minimally-swelling, biocompatible and biodegradable in vivo [4]. We used hyaluronan-oxime to deliver colloidal drug aggregates of timolol-prodrugs, which were efficacious in reducing intraocular pressure - critical in the treatment of glaucoma [5]. Synakis, a spin-off company from our lab, is now advancing the hyaluronan-oxime hydrogel towards clinical trials.

References

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HEALTHCARE
Professor Sarah Heilshorn
Stanford University, USA

Sarah Heilshorn is the Rickey/Nielsen Professor of Engineering & Chair of the Department of Materials Science & Engineering at Stanford University, where she is also a Bass University Fellow in Undergraduate Education. Her laboratory integrates concepts from materials science & protein engineering to design new, bioinspired materials for 3D bioprinting, regenerative medicine, & human tissue modeling. She has been recognized with the Senior Scientist Award from the International Society for Biofabrication, a New Innovator Award from the National Institutes of Health (USA), & the Career Award from the National Science Foundation (USA). She is an elected Fellow of the American Institute for Medical & Biological Engineering & currently serves as an Editor for Acta Biomaterialia & on the Board of Directors for the Tissue Engineering & Regenerative Medicine International Society (TERMIS) North America chapter.

Dynamic Materials for Biofabrication of Personalized Tissue Mimics

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Abstract

During development and disease, a cell's behavior is directly influenced by its surrounding microenvironment. Thus, when designing organoid models, ideally each cellular sample would be cultured in its own customizable biomaterial that matches the specific state found *in vivo*. To fulfill this need, my lab designs bespoke biomaterials that can be tailored to fit a range of applications. In one demonstration, I present a family of adaptable biomaterials that support the growth of patient-derived pancreatic ductal adenocarcinoma (PDAC) organoids [1]. Through control of the matrix, we find that PDAC becomes significantly more chemoresistant in stiffer matrices due to mechanosignaling through CD44 receptors, which leads to upregulation of efflux pumps. Excitingly, this chemoresistance is reversible, with PDAC regaining sensitivity to frontline chemotherapy upon softening of the matrix or blockade of CD44 signaling. In a second example, I discuss how matrix biomechanics can influence the earliest morphogenetic processes during neural organoid differentiation [2]. Through tuning of the matrix viscoelasticity, we can achieve three-dimensional neural rosettes with highly conserved structural organization. This reproducible stereotyping of tissue morphogenesis enables the identification of early developmental abnormalities in cells from patients with the genetic disorder 22q11.2 Deletion Syndrome (DiGeorge Syndrome). Together, these examples demonstrate how fundamental materials science knowledge can be used to develop unique tools for the creation of patient-derived tissue models.

References

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ORAL PRESENTATIONS

SUSTAINABILITY & ENERGY

Rapid and Sustainable Strategy for Lithium-Ion Battery Recycling and Upcycling

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Abstract

The rapid growth of lithium-ion battery deployment in electric vehicles and grid energy storage is expected to generate a significant volume of end-of-life batteries in the coming decade.1 Among various cathode chemistries, lithium iron phosphate (LiFePO4, LFP) batteries are increasingly dominant due to their safety, long cycle life, and low cost.2 However, current recycling technologies for spent LFP cathodes remain inefficient because of the relatively low economic value of iron and the energy-intensive, multi-step processes typically required for material recovery. Developing fast, selective, and sustainable recycling strategies is therefore essential to support a circular battery economy.

In this work, we present a rapid and selective recycling approach for spent LFP cathodes based on a deep eutectic solvent (DES)-assisted carbothermal shock process.2 The method integrates the unique solvating capability of DES with an ultrafast thermal shock treatment to enable efficient lithium extraction and structural transformation of the cathode materials (Figure 1). The DES system facilitates selective interaction with lithium species, while the carbothermal shock process provides rapid heating that promotes phase conversion and separation of valuable components within seconds.

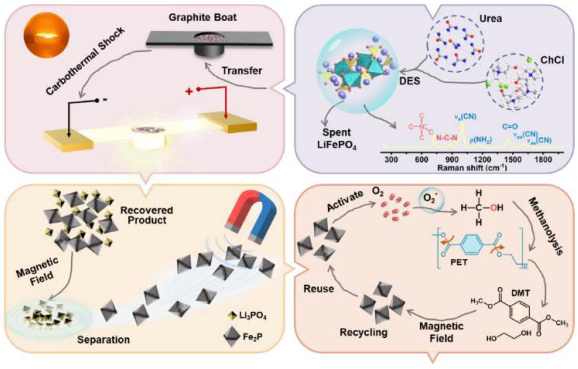

Figure 1. Scheme of a rapid and sustainable strategy for LiFePO4 battery recycling via deep eutectic solvent-assisted carbothermal shock.

The proposed strategy enables efficient recovery of lithium and iron-containing products with high selectivity and significantly reduced processing time compared with conventional hydrometallurgical or pyrometallurgical routes. Structural and compositional analyses reveal that the combined DES-thermal treatment effectively breaks down the LFP crystal framework, allowing lithium to be rapidly released while preserving the integrity of the recovered iron phosphate phase. The process also minimizes chemical consumption and secondary waste generation.

This work demonstrates a promising pathway for the sustainable recycling of LFP batteries using a rapid and scalable approach. By coupling green solvent chemistry with ultrafast thermal processing, the strategy provides new opportunities for efficient resource recovery from next-generation battery waste and contributes to the development of a more sustainable battery lifecycle.

References

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Carrier Localization in Pnictogen-Based Chalcohalides from Defect-Bound Hot Polarons

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Abstract

Pnictogen-based solar absorbers have gained prominence as promising nontoxic and stable alternatives to lead-halide perovskites (LHPs), but are severely limited by carrier localization, preventing their performance from approaching those of LHPs. Recent efforts have uncovered routes to overcome carrier localization, but these early efforts only considered intrinsic factors. Herein, we push beyond these limited early efforts, examining the role of defects, not only on cold carriers but also hot carriers. Focusing on the structurally one-dimensional pnictogen chalcohalide BiSBr, we find that whilst this material intrinsically does not exhibit carrier localization, vacancies introduced during synthesis lead to pronounced extrinsic self-trapping via the formation of defect-bound hot polarons—excited charge-carriers strongly coupled to local defect-induced vibrational modes. These above-gap defect states divert hot carriers from cooling to the band edge, thus depleting the mobile carrier population. Our findings establish the key role of defect-bound hot polarons in mediating extrinsic localization and offer new mechanistic insights into the interplay between defects, lattice coupling, and excited-state charge-carrier transport, which are critical to designing efficient perovskite-inspired solar absorbers.

Protein-Based Soft Materials from Agricultural Byproducts for Resilient Food and Agricultural Systems

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Abstract

Functional polymeric materials play a critical role in food systems, supporting processes such as post-harvest handling, processing, shipping, and retail. The development of bio-based sustainable functional materials has become a long-term goal in materials research, driven by growing concerns over global warming and plastic pollution. Agricultural byproducts, rich in biomacromolecules such as proteins, represent a significant yet underutilized resource, particularly for high-value applications. Over the past decade, our research has focused on understanding and controlling the structure of biomass-derived proteins to transform agricultural byproducts into functional soft materials with tunable structure–property relationships. Strategies to improve the processability of plant proteins were explored using soy protein as a model biomacromolecule. Combined chemical and physical treatments were employed to modify protein conformation and intermolecular interactions, enhancing processability and enabling the development of protein-based functional materials. Building on this foundation, a series of sustainable bio-derived materials were designed to address challenges in food and agricultural systems, with applications in food safety, food security, and sustainability.

The first platform, “Jelly Ice,” is a fully bio-derived, reusable cooling medium engineered from protein hydrogels as sustainable cooling alternatives. Unlike traditional ice, Jelly Ice provides tunable cooling performance without generating meltwater, eliminating a major source of microbial cross-contamination, food spoilage, and quality deterioration. This fully bio-derived material also reduces reliance on petroleum-derived plastics of current cooling solutions. Over seven years, five generations of prototypes were developed by tailoring composition-structure-property relationships for applications ranging from food preservation to life sciences and pharmaceuticals. A theoretical framework integrating descriptive and mathematical models was developed, advancing fundamental scientific understanding and providing design principles of hydrogel-based cooling materials, enables future development of this emerging field. The second platform is a sustainable, removable antimicrobial and antifouling coating for hydrophobic food-contact surfaces such as LDPE. Formed through a crosslinked network of tannic acid, gelatin, and soy protein hydrolysates, the coating combines robust surface adhesion with removability and halamine-forming capability. The resulting surfaces exhibit rapid contact-killing activity, inhibit biofilm formation, and achieve up to 5 $\log_{10}$ CFU cm^{-2} reductions against both *Escherichia coli* and *Listeria innocua*, demonstrating strong potential for improving food safety in food processing facilities. The third platform addresses food security by developing edible scaffold materials for cellular agriculture, an emerging approach to meeting growing global protein demand sustainably. Stable and editable soy protein isolate-based scaffolds were engineered through fructose-induced controlled Maillard conjugation coupled with simultaneous sterilization, which supported *C2C12* myoblast growth and demonstrated cytocompatibility. This work establishes a scalable, food-compatible platform for cellular agriculture, supporting future solutions for global food security.

Collectively, these studies demonstrate how fundamental control of biomacromolecular interactions can enable the rational design of sustainable functional biomaterials from agricultural byproducts. By connecting molecular-level understanding with macroscopic performance, this work highlights opportunities to advance food safety, food security, waste valorization, and circular bioeconomy initiatives through bio-based materials innovation.

Molecular Dynamics Investigation of Water Interfacial Behavior on Defective Hexagonal Boron Nitride (hBN) Surfaces

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Abstract

Hexagonal Boron Nitride (hBN), often referred to as "white graphene," is a wide-bandgap 2D material that has gained significant traction in the fields of nanofluidics, energy storage, and biosensing. Its unique combination of atomic smoothness, high thermal stability, and chemical inertness makes it an ideal candidate for next-generation membranes. Unlike its carbon-based counterpart, graphene, the polar nature of the B-N bonds in hBN creates a complex electrostatic environment at the solid-liquid interface. Recent theoretical studies have highlighted how this polarity leads to distinct interfacial chemistries and friction characteristics that decouple slip from wettability [3]. However, in real-world applications, 2D sheets are rarely pristine; atomic-scale vacancy defects are inevitable and can profoundly alter the material's functional properties. Understanding how these defects influence the surrounding water structure is critical for optimizing hBN-based devices.

This research utilizes classical molecular dynamics (MD) simulations to systematically investigate the structural stability and water density profiles of hBN monolayers containing controlled vacancy defects. Our analysis reveals that water orientation exhibits distinct preferences depending on whether the defect is a boron or nitrogen vacancy. The simulations were performed using the LAMMPS package with a large simulation box (108x110x100 Å) containing approximately 15,000 water molecules to ensure a well-solvated environment. The interactions were guided by established hBN-water force field parameters derived from high-level electronic structure calculations [1, 2], which accurately capture the van der Waals and Coulombic contributions.

We focused on a range of configurations, contrasting pristine hBN with systems containing one to four atomic vacancies, including single boron (1B), single nitrogen (1N), and mixed vacancy types (1B1N, 1B3N, 1N3B). To achieve high-resolution insights into the hydration layers, we developed in-house scripts for localized density analysis. Instead of traditional planar averages, this approach calculates the oxygen density within specific cylindrical regions (radius of 3.0 Å) centered directly at the defect sites. Our preliminary results indicate that both vacancy type and count significantly perturb the local atomic packing and the resulting water distribution. Notably, boron vacancies (1B) exhibit a significantly higher first density peak compared to nitrogen vacancies (1N), suggesting a stronger attraction toward water molecules. Visual analysis confirms that water molecules tend to orient their hydrogen atoms toward the boron vacancy sites—a behavior that deviates significantly from the relatively hydrophobic nature of pristine hBN. This investigation into water structures provides fundamental insights into the underlying mechanisms that may govern chemical reactivity at these defect sites.

Furthermore, we evaluate how these localized hydration peaks influence the broader electrochemical environment. Specifically, we discuss how the observed hydration shells provide a basis for characterizing the preferential interactions between water molecules and the specific of Boron or Nitrogen atoms of the surface. This site-specific behavior reveals a localized structure that is often overlooked in classic electric double layer theories

(EDL), which typically treat solid-liquid interfaces as uniform, homogenized charged planes. Our 3 results atomic-scale vacancies in the hBN monolayer suggesting that the initial stage of EDL formation is highly heterogenous. The insights gained from this study are essential for tailoring the sensitivity of hBN-based biosensors and the efficiency of nanocarriers. Future work will expand these models to include multilayer hBN systems and investigate the effects of added ionic species in the system to further elucidate the potential for defect-engineered 2D materials in advanced electronic and separation technologies.

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CALPHAD-guided Screening and Experimental Validation of Refractory Multi-principal Element Alloys for Additive Manufacturing

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Abstract

Refractory multi-principal element alloys are candidate materials for structural components exposed to high temperature and severe thermal cycling. Their compositional complexity provides a large design space, but it also increases the experimental cost of alloy development. This work combines CALPHAD calculations, arc melting, heat treatment, diffraction, electron microscopy, thermal analysis, and laser remelting to identify refractory alloys with stable body-centred cubic phase constitution and practical laser processability.

The Hf-Mo-Nb-Ta-Ti-Zr system was screened using Thermo-Calc with the TCHEA database. Equilibrium and Scheil-Gulliver solidification calculations were used to define ternary compositions with full body-centred cubic phase fraction, constrained liquidus temperature, limited solidification range, and reduced predicted hot-cracking susceptibility. Six ternary alloys were selected for experimental validation. The alloys were produced by arc melting and analysed in the as-cast and heat-treated states. Attention was given to $Nb_{25}Ti_{20}Zr_{55}$, which exhibited a low calculated Clyne crack-susceptibility coefficient and a low density relative to Hf- and Ta-rich compositions.

Laboratory X-ray diffraction showed that several selected alloys formed a dominant body-centred cubic phase at room temperature. Heat treatment at 1350 °C for 1 h retained the body-centred cubic phase constitution in the most promising compositions. Transmission electron microscopy of $Nb_{25}Ti_{20}Zr_{55}$ showed sharp body-centred cubic selected-area electron diffraction patterns and chemically uniform contrast at the investigated length scale.

Laser remelting experiments were used as a first processability assessment. Cross-sectional microscopy showed continuous remelt tracks without solidification cracking or large porosity under the investigated conditions. After this validation, alloy has been fabricated as powder feedstock for LPBF and DED via ultrasonic atomisation. Both routes yielded a wide processing window and dense builds under the investigated conditions.

These results show that CALPHAD-assisted screening can compress the experimental search and identify refractory compositions that meet phase stability, low predicted cracking tendency, and laser processability simultaneously. The framework links thermodynamic down-selection to an operational crack-free remelt criterion and onward to additive manufacturing of refractory MPEAs by LPBF and DED.

Revealing Atomic-scale Dynamics in Materials and Devices via In-situ TEM

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Abstract

In-situ transmission electron microscopy (TEM) has emerged as a powerful platform for probing dynamic processes in materials at the atomic scale. In this talk, I will present two complementary studies that leverage in-situ TEM to reveal fundamental mechanisms governing phase transformations in intermetallic alloys and breakdown phenomena in nanoscale spintronic devices.

First, we investigate atomic-scale phase transformation pathways in the Pt–Sn intermetallic system using in-situ thermal TEM. Multiple transformations, including $PtSn_4 \rightarrow PtSn_2$, $PtSn_2 \rightarrow Pt_2Sn_3$, and $PtSn_2 \rightarrow PtSn$, are directly triggered and monitored. Real-time scanning TEM (STEM) imaging, diffraction, and compositional analysis uncover distinct transformation behaviors, crystallographic orientation relationships, and atomistic pathways. Notably, transient atomic modulations and intermediate phases are observed, highlighting the complexity of diffusion-mediated transformations and the critical role of crystal structure in determining transformation mechanisms.

Second, we explore electrical breakdown mechanisms in perpendicular magnetic tunnel junctions (PMTJs), key components in next-generation magnetic random-access memory (MRAM), using in-situ biasing STEM. Atomic-resolution imaging combined with spectroscopy reveals electromigration-driven structural evolution under applied bias. Two distinct breakdown modes are identified: (i) soft breakdown, characterized by gradual tunnel magnetoresistance degradation due to pinhole formation and edge conduction paths, and (ii) complete breakdown, driven by Joule heating and mass transport that leads to melting of electrodes and the tunnel barrier. Reversible redistribution of Fe and Co atoms at low bias further highlights the dynamic nature of atomic transport in operating devices.

Together, these studies demonstrate how in-situ TEM enables direct visualization of atomic processes across different material systems and external stimuli (thermal and electrical). By capturing real-time structural and chemical evolution, this approach provides critical insights into phase stability, transformation kinetics, and device reliability. The findings underscore the versatility of in-situ TEM as a unifying tool for understanding dynamic phenomena in both structural and functional materials, and for guiding the design of advanced materials and nanoscale devices.

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Bio-Inspired Synergistic Design for Balancing Energy Dissipation and Electromagnetic Interference Shielding

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Abstract

Next-generation aerospace and communication systems demand advanced structural materials that can simultaneously provide exceptional mechanical toughness and electromagnetic interference (EMI) shielding [1]. Traditional EMI shielding primarily relies on metallic materials and conductive composites, which face limitations including high density, poor corrosion resistance, secondary radiation pollution through reflection, and a trade-off in which the high filler loadings required for effective shielding compromise mechanical performance and processability [2]. Recent studies have introduced bio-inspired geometries, such as triply periodic minimal surfaces (TPMS) and honeycomb architectures, to reduce the degradation in quasi-static mechanical performance associated with high conductive filler loading [3,4]. However, their dynamic energy dissipation behavior remains largely unexplored, despite its critical importance for aerospace and communication systems subjected to vibration, impact, and cyclic loading.

Addressing this challenge, this study aims to develop a multifunctional architected framework that mitigates the conventional trade-off between electromagnetic attenuation and dynamic mechanical responses. By tailoring the structural architecture, the framework enables simultaneous control of EMI shielding performance and energy dissipation behavior, providing enhanced load resistance while maintaining effective electromagnetic protection. To accelerate the discovery and evaluation of multifunctional architectures, this project will develop a self-driving experimental platform that automates the entire workflow, including fabrication, EMI characterization, and mechanical testing. By integrating automated experimentation with data-driven design optimization, the proposed framework enables rapid and reliable exploration of architected materials.

At the structural level, bio-inspired helicoidal (bouligand) architectures are employed to leverage their exceptional damage tolerance and impact resistance. The helicoidal arrangement promotes crack deflection, crack twisting, and progressive delamination, thereby enhancing energy dissipation and delaying catastrophic failure [5]. Architected structures featuring unidirectional, periodic, and gradient bouligand configurations will be investigated, with systematic variations in strut thickness and spacing to tailor both electromagnetic and mechanical responses. The designs will be fabricated using fused filament fabrication (FFF) with conductive polymer filaments. Their multifunctional performance will then be evaluated through electromagnetic characterization, including scattering parameter measurements and EMI shielding effectiveness analysis, alongside instrumented drop-impact testing to quantify energy dissipation and impact resistance. To improve the generalizability of this framework across materials systems and application requirements, multi-physics simulations will be coupled with physics-informed surrogate models to capture the complex interplay between design parameters and multifunctional responses. Bayesian optimization will be integrated to autonomously identify optimal architectures and establish generalizable structure–property relationships across diverse performance requirements.

Ultimately, this self-driving framework establishes a scalable pathway for the autonomous discovery of multifunctional architected materials, enabling precise tailoring of both energy dissipation and electromagnetic attenuation to application-specific requirements. By

integrating bio-inspired structural design, multi-physics modeling, and closed-loop experimental optimization, the proposed approach addresses the longstanding trade-off between structural integrity and functional performance, paving the way for next-generation aerospace, defense, and telecommunication systems.

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New Method to Characterize Automotive Sheet Metals in Tension and Compression during In-Plane Bending

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Abstract

Decarbonization and electrification have spurred the development of sustainable, high-performance lightweight metals. High-strength aluminum alloys are crucial to reducing the vehicle weight, enhancing fuel efficiency in gas-powered vehicles, and offsetting the added mass of battery packs in electric vehicles (EVs), while satisfying crash safety. Widespread adoption of these emerging materials in the vehicle structure requires accurate simulations with constitutive models to industrially-relevant strains. To address this, a hybrid experimental-numerical approach is proposed to characterize tension-compression asymmetry of automotive sheet metals. For this purpose, a novel in-plane bending test equipped with stereoscopic Digital Image Correlation (DIC), as shown in Figure 1, has been adopted to retrieve the compressive stress-strain behavior to strains in excess of 20% using constrained inverse finite-element analysis. The new method revealed that AA5182-O and AA6xxx-T4 and -T7 alloys did not exhibit tension-compression asymmetry in contrast to the E-Form Plus® magnesium alloy. Electron backscatter diffraction (EBSD) was conducted to reveal twinning-induced deformation mechanisms in the magnesium alloy that manifested in a sigmoidal-shaped compressive stress-strain response on a macroscopic length scale.

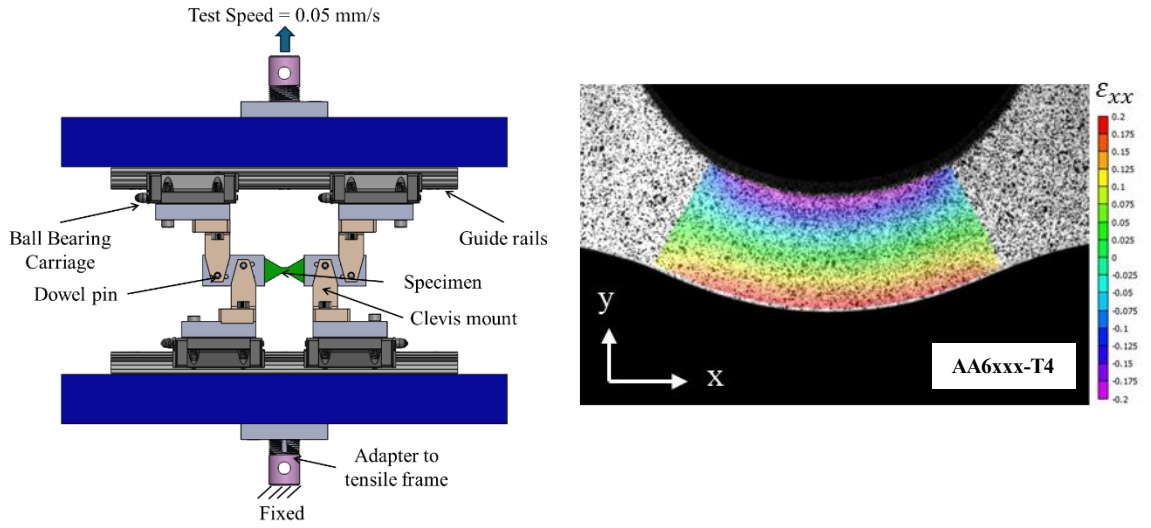

Figure 1: Design of the in-plane bending test (left), and resulting strain distribution in the sample (right) measured using Digital Image Correlation (DIC).

Optimization of Organic Photodetecting Devices Towards Infrared Applications

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Abstract

Photodetector devices that are able to convert infrared photons into electrical signals are increasingly crucial for emerging applications such as automatic driving, biomedicine and advanced surveillance. However, traditional high-performance technologies such as InGaAs are extremely expensive and energy-intensive to process, which hampers availability in consumer market. In this context, organic photodetectors (OPDs) are highly promising due to the chemically tunable absorption wavelength, cheap and low-energy fabrication, mechanical flexibility, and biocompatibility, although many challenges emerge when OPDs target infrared wavelengths.

In this presentation, some of the currently available strategies to optimize OPD performance for targeted applications will be explored, introducing examples of improving both the chemical design of photodetecting small molecules and the design of the OPD architecture. In particular, the importance of geometry of photoactive molecules[1], of the electrostatic interactions in organic thin films[2] and of precise control of photoactive layer composition[3] will be explored.

Finally, some strategies will be highlighted to push the spectral detection region towards longer wavelengths for infrared applications of OPDs with competitive figures of merit. In particular, the focus will be on increasing the charge transfer character of the photoactive system, since charge transfer states formed between electron-donor and electron-acceptor species have lower energy than intrinsic bandgap of absorbers and can be dissociated with minimal driving power. In the presentation, examples of both intermolecular and intramolecular charge transfer enhancement will be discussed, as a promising way to achieve efficient infrared photodetection in organic materials.

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Unravelling the Role of Polyelectrolyte Brushes in Synaptic Devices

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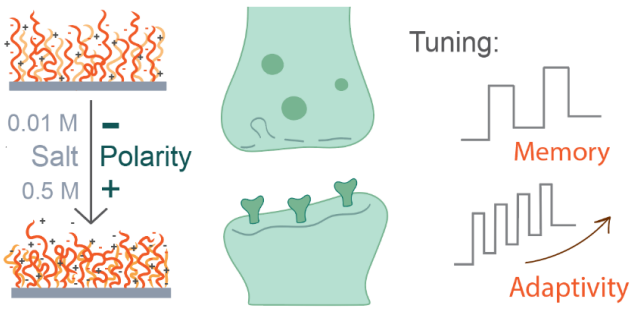
Abstract

Our brains are capable of high-density, low-power memory storage owing to the dynamic potentiation and depression of synapse potentials. Artificial synapses can emulate the dynamic behavior of synapses by switching conductivity states through electronic or ionic signals. The latter is referred to as the field of iontronic synapses. It is interesting to consider polymers as the memory-active material in iontronic devices, as they allow for additional bio-compatibility, flexibility, low-energy consumption and tunability.

Circumventing the need for complicated synthetic procedures, we can use simple, charged polymers as the memory-active material in iontronic synapses. In such materials, the driving force for synaptic behavior is based on ion transport. However, instead of adding complexity to the active material, the complexity now resides in the design of the device geometry, which is needed to make this memory-enabling ion transport work. In our research, we have investigated whether the use of simple, charged, stimuli-response polymers will allow us to use a simple device geometry as well.

We have used polyelectrolyte brushes as the stimuli-responsive material. These brush structures comprise of densely end-grafted and charged polymer chains on a surface, which are able to tune ion transport.1 When exposed to varying salt solutions or an applied potential, brushes can restructure through the collapse or stretching of their grafted chains (Scheme 1). This dynamic behavior suggests that polyelectrolyte brushes might exhibit iontronic, synaptic behavior without additions of a specific device geometry.

In our work, we set out to investigate the role of polyelectrolyte brushes in synaptic devices. First, with electrochemical impedance spectroscopy (EIS) and chronoamperometry, we have studied transient processes related to ion transport. Second, with synaptic tests such as paired-pulse testing, spike-rate and spike-number dependent plasticity experiments, we have studied the synaptic behavior (Scheme 1) of our brushes in relation to these transient processes. We were able to discern that the role of polyelectrolyte brushes is two-fold, relating to 1) local ion concentration and 2) charging effects. The obtained results help open up the field of iontronic, polymer brush-based neuromorphic devices, and lay the foundation for designing of future simple, fluidic, biocompatible electronic interfaces.



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Development of Novel Multi-Element Metal Sulfide Nanosheets

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Abstract

In recent years, multi-element nanoparticles (NPs), particularly high-entropy alloys (HEAs), have emerged as a frontier in materials science. These systems offer significant potential for catalysis and other applications by leveraging synergistic effects between multiple constituent elements[1]. This research paradigm has recently evolved from simple alloys to more complex multi-element ceramics, such as high-entropy oxides and sulfides. Among these, multi-element metal sulfides are of particular interest due to their vast compositional and structural degrees of freedom, which enable precise tuning of their electronic states and chemical properties. Despite their potential, the synthesis of compositionally complex sulfides is often hindered by the different reactivities of each metal precursor, which frequently results in undesired phase separation. This challenge has limited the exploration of multi-element sulfide NPs, especially those incorporating early transition metals to form transition metal dichalcogenides (TMDs). These materials are highly valued for the unique properties that arise from their characteristic 2D layered architectures.

In this study, we demonstrate a wet chemical synthesis of multi-element metal sulfide nanosheets composed of various early transition metals via the reaction of metal ions with carbon disulfide in an oleylamine solution. Structural analysis revealed that the final crystal structure was dependent on the specific combination of constituent elements. In some cases, the synthesized nanosheets adopted structures distinct from the most stable 2H-MoS_2 like phase. Furthermore, these multi-element TMD NPs exhibited unique catalytic properties due to their structures. These findings suggest that the integration of multiple elements not only stabilizes the layered MoS_2-type structure but also induces unique electronic environments, opening new avenues for the design of high-performance functional materials.

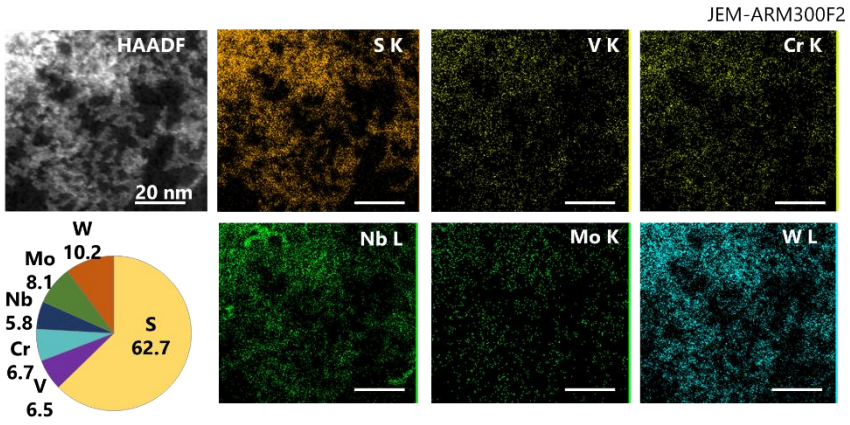

Figure. HAADF-STEM image and corresponding EDX elemental maps of (VCrNbMoW)S_x nanosheets, along with their elemental composition determined by XRF.

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Modular, Thermally Driven Asymmetric Micro-Actuators for Untethered Soft Robotic Locomotion

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Abstract

The boundary separating living organisms from inanimate matter is agency: the unique ability to seamlessly harness ambient energy and convert it into coordinated, non-reciprocal mechanical work [1]. In highly viscous, low-Reynolds-number environments, where time-reversible, symmetric deformations yield zero net displacement, nature achieves this autonomous motion through elegant spatiotemporal asymmetry. Ciliary arrays demonstrate this adaptation, executing distinct power and recovery strokes that break the trap of reversible motion to create a strictly one-way cycle that drives purposeful movement [1].

Replicating this intrinsic biological intelligence within synthetic soft matter is critical for developing next-generation, untethered, autonomous microscopic machines. While conventional multi-material hydrogels suffer from severe interfacial delamination and sluggish swelling kinetics, we bypass these physical flaws by encoding kinetic asymmetry directly into chemically homogeneous materials [2]. By leveraging the inherently faster water diffusion in macro-porous polymer networks compared to dense ones, we establish a hard-coded structural asymmetry. This effectively transforms the material into a robust, autonomous monolithic ratchet.

Using high-resolution DMD-based microstereolithography, we translate this porosity-driven principle into intricate, highly programmable 3D architectures. Harnessing this structurally encoded intelligence, we demonstrate autonomous robotic functions driven solely by uniform global temperature fluctuations. We developed a micro-rotator capable of continuous directional rotation and a centipede-inspired soft robot that successfully translates non-directional thermal cycles into forward crawling. By reconfiguring these asymmetric subunits as programmable micro-actuators [3], we created multi-functional soft actuators capable of cooperative tasks. Scaling this material-based ratchet into modular geometries reliably generates advanced locomotive gaits. These bioinspired architectures achieved sustained, predictable forward motion across numerous thermal cycles.

By bridging the critical gap between passive matter and active, self-sustained motion, we are breathing kinetic agency into synthetic soft materials. We are fundamentally redefining what synthetic structures can achieve, bringing artificial micro-actuators a definitive step closer to the autonomy, resilience, and profound intelligence characteristic of complex living organisms.

Acknowledgments: This project was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under project number WA 3084/19-1.

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Self-propelled Pectin Micromotors for Enhanced Penetration and Drug Delivery to In-vitro Breast Cancer Cells

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Abstract

Passively diffusing micro/nanocarriers based cancer therapeutics suffer from limited tumour penetration and cellular uptake. While self-propelled micro/nanomotors present as alternatives, their predominant inorganic composition hinders clinical translation. Hence, this study reports the fabrication of self-propelling micromotors derived from pectin polysaccharides, powered by H2O2 decomposition by the asymmetric surface platinum coating (Figure 1). Their self-propulsion is characterized through mean-square displacement and optical tweezers based analysis. They exhibit enhanced penetration into extracellular matrix simulant compared to passive counterparts. The 5-fluorouracil-loaded micromotors with H2O2 fuel availability (5% w/v) display 25-fold faster drug release than fuel-devoid micromotors. In-vitro assays confirm the micromotors' biocompatibility with human embryonic kidney cells. Contrarily, self-propelling drug-loaded micromotors show superior cytotoxicity against breast cancer cells with 10-fold lesser half-maximal inhibitory concentration than passive microcarriers. Cellular internalization measurements reveal a 21% increase in intracellular platinum content in cancer cells treated with micromotors with H2O2 fuel availability, indicating enhanced cellular uptake rates driven by their active motion. Furthermore, the anti-angiogenesis potential of self-propelling drug-loaded micromotors is confirmed by an ex ovo chorioallantoic membrane assay. Overall, this work showcases the development of active drug carriers holding tremendous potential to be used in breast cancer therapy.

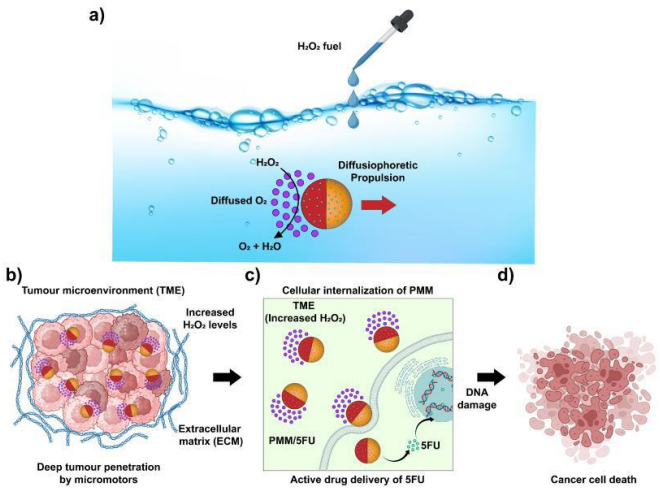

Figure 1: (a) Diffusiophoretic propulsion mechanism of micromotors, Schematics illustrating the enhanced tumour penetration (b), cellular internalization, and cancer cell death induced by the micromotors.

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Bio-based Materials for Continuous Monitoring of *E. coli* in Urinary Catheters: TimeUp Device

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Abstract

Catheter-associated urinary tract infections (CAUTIs) represent a significant global healthcare challenge, contributing to increased morbidity, mortality, and substantial economic impact. Current diagnostic procedures are reactive and time and resource-consuming. The sample collection and laboratory analysis are always triggered by the manifestation of symptoms or signs, and the results can take up to three days to be obtained. This work presents the development of TimeUp (Technology for Infection Monitoring and Evidence of Uropathogens), a novel near-patient device designed for the continuous and autonomous monitoring of urine to specifically detect the presence of Escherichia coli (E. coli).

The main innovation lies in the synthesis of specialized polymeric matrices using glucose-based polyurethane (PU) foams. By employing glucose as a bio-polyol, the material not only reduces environmental impact but also serves as a bacterium-attracting agent. In a first stage, the PU foams were optimized through a Quality by Design (QbD) approach using a Design of Experiments (DoE) study to maximize water sorption and capillarity while ensuring structural integrity. To enable detection, the matrices were functionalized with primary amine groups via polyethyleneimine (PEI) entrapment, allowing the subsequent chemical immobilization of the chromogenic agent X-Glu (5-Bromo-4-chloro-3-indolyl-β-D-glucuronide sodium salt).

In the presence of E. coli (pathogen responsible for approximately 80% of UTIs), the immobilized substrate reacts with a specific enzyme, leading to the formation of a blue colored compound visible to the naked eye. However, in a pilot laboratory setup for continuous testing simulating a real clinical scenario, the samples showed low retention of the blue color compound after the reaction. To improve the device's performance, composite materials combining polyurethanes with cellulose matrices were developed, and cellulose nitrate filters were also added to improve color retention. The final results demonstrated that even after 12 days of leaching with bacteria-free medium (simulating normal urine), when substituted by medium simulating contaminated urine, the matrices were able to detect E. coli at concentrations as low as 10^3 CFU/mL (below the standard infectious threshold of 10^5 CFU/mL) in only 30 hours. This way, the device enables the early detection of E. coli in catheterized patients' urine without requiring decision-making or sample collection, and before the progression to an infection and development of symptoms.

This work integrates materials science with preventive clinical practice, offering an innovative, sustainable, and low-cost technology to improve patient care, combat antibiotic resistance, and reduce the costs associated with hospital-acquired infections.

Mg–Na Doped HA 3D-Printed Scaffolds Enhance Bone Regeneration in Critical-Sized Defects

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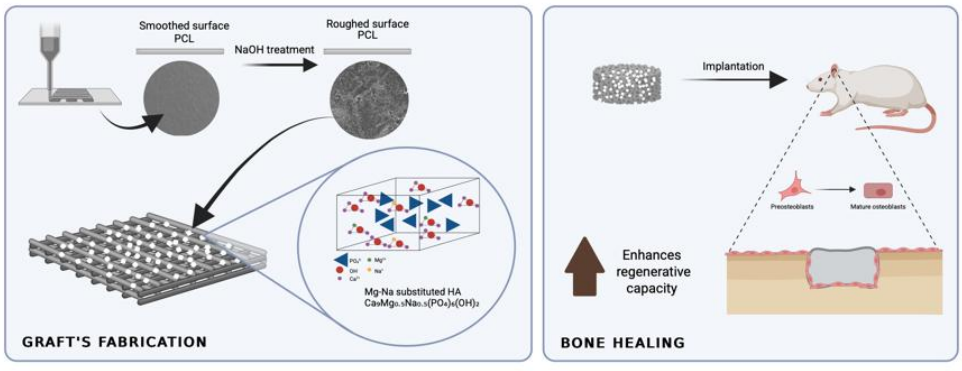
Abstract

Critical-sized bone defects remain a major clinical challenge due to their inability to undergo spontaneous healing. Although autologous bone grafting is considered the gold standard, its clinical application is limited by donor site morbidity, limited availability, and surgical complexity. Therefore, the development of synthetic biomaterials that can mimic the biological and structural properties of natural bone while promoting regeneration is highly desirable. In this study, we developed a nanosized magnesium- and sodium-doped hydroxyapatite (Mg–Na–HA) incorporated into a three-dimensional (3D)-printed polycaprolactone (PCL) scaffold as a potential bone graft for critical-sized defects.

Characterization confirmed crystalline HA, with Mg–Na substitution altering lattice parameters and reducing nanoscale grain size (<100 nm). Both materials showed good biocompatibility, with Mg–Na–HA exhibiting lower hemolysis and enhanced osteogenic differentiation, as indicated by increased ALP activity and mineralization. 3D-printed PCL grafts with a gyroid structure were selected for optimal mechanical strength, while alkali treatment improved surface properties and ceramic incorporation. All grafts supported cell viability, with Mg–Na–HA/PCL showing improved outcomes. *In vivo*, Mg–Na–HA/PCL significantly enhanced bone formation in critical-sized defects compared to HA/PCL and PCL, demonstrating its potential as an advanced bone graft.

In conclusion, Mg–Na–HA/PCL grafts exhibit favorable physicochemical properties, excellent biocompatibility, and enhanced osteogenic activity, making them a promising alternative to conventional bone grafts for the treatment of critical-sized bone defects.

Keywords: biomaterial, bone scaffold, hydroxyapatite, nanomaterial, osteogenesis, 3D printing



Graphical Abstract. 3D-printed PCL grafts functionalized with Mg–Na–doped hydroxyapatite enhance osteogenesis and bone regeneration in critical-sized defects.

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