HARBIN INSTITUTE OF TECHNOLOGY
NEWSLETTER 2024 ISSUE 1

HIT TIMES

EMBRACING THE BEAUTY OF AUTUMN: A GLIMPSE INTO CAMPUS LIFE AT HIT

HIT TIMES

Harbin Institute of Technology Newsletter
2024 ISSUE 1

The Journal of HIT TIMES is a dedicated publication for the alumni and friends of the Harbin Institute of Technology (HIT), produced by the HIT Journal Center. This journal serves as a vital platform for sharing news, achievements, and developments related to the university community.

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CONTENTS

Research & Academia

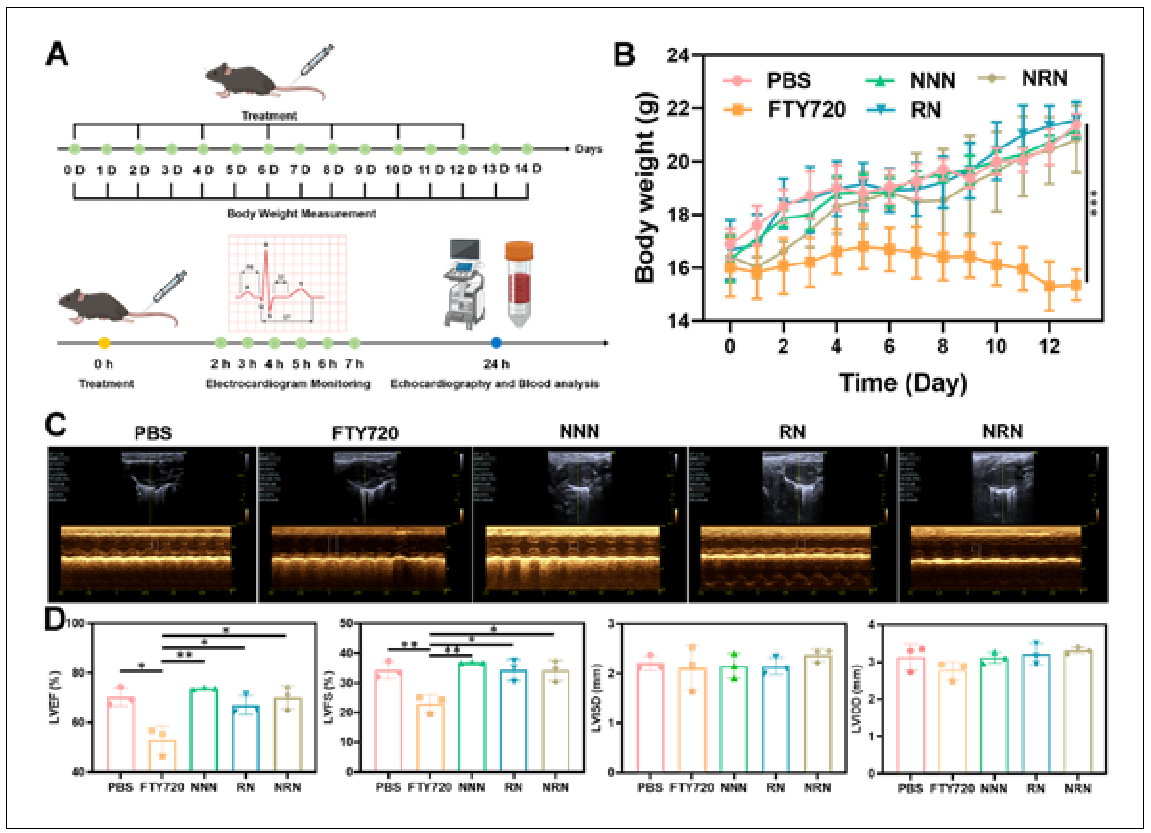
News & Events

A NEW STUDY ON TARGETED DRUG DELIVERY FOR EFFECTIVE INFLAMMATION SUPPRESSION AT STROKE SITES

Professor Kuikun Yang's group at the School of Life Science and Technology of Harbin Institute of Technology has made significant progress in the field of inflammation suppression in ischemic stroke. Their findings titled **Neutrophil Membrane-Camouflaged Polyprodrug Nanomedicine for Inflammation Suppression in Ischemic Stroke Therapy** were published in *Advanced Materials*, providing new insights into the application of nanomedicine in ischemic stroke treatment.

Ischemic stroke is characterized by brain tissue damage due to the sudden blockage of blood vessels in the brain, resulting in high incidence, mortality, disability, and recurrence rates. Current treatments for ischemic stroke focus on early reperfusion to rescue damaged neurons at the stroke site. However, reperfusion can lead to inflammatory responses with local elevation of Reactive Oxygen Species (ROS), thus resulting in secondary neural tissue damage. Therefore, effective control of brain ischemia-reperfusion injury is crucial for protecting brain tissues at the stroke site and restoring their function.

Fingolimod, an FDA-approved Sphingosine-1-Phosphate Receptor (S1PR) modulator for the clinical treatment of multiple sclerosis, has shown potential to alleviate stroke-induced neurological damage. However, the protective effects of fingolimod on neural damage are dose-dependent, while the presence of the blood-brain barrier limits the entry of most



Research & Academia
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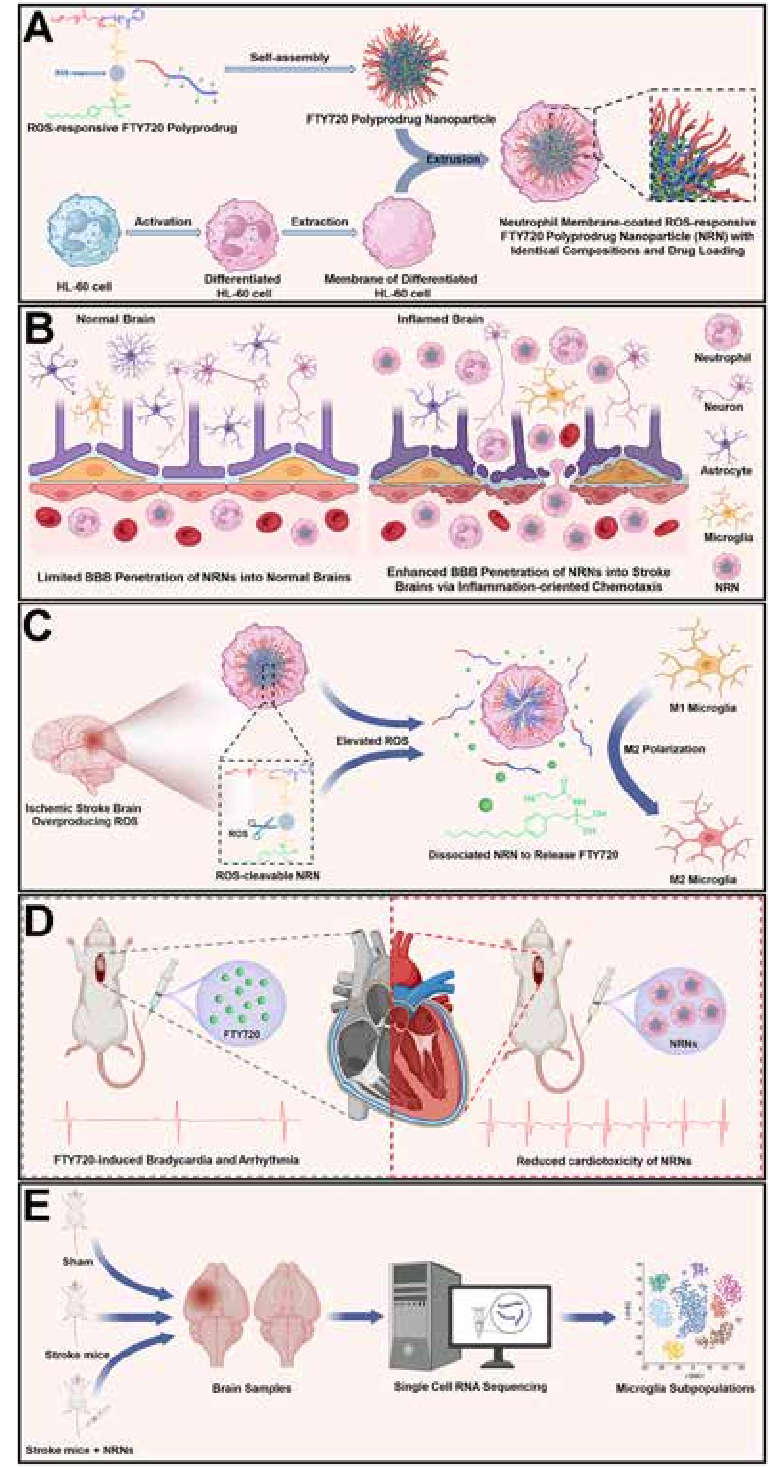
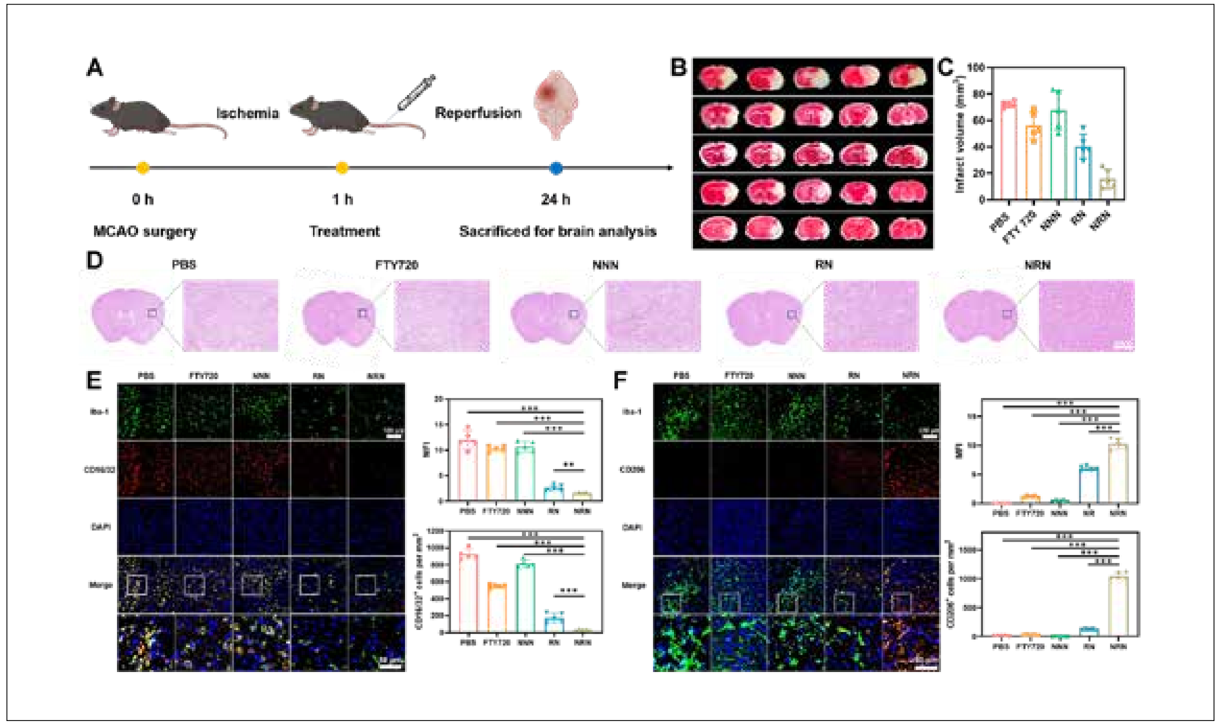
fingolimod into the stroke site to exert its effects. Additionally, high doses of orally or intravenously administered fingolimod can lead to severe cardiac toxicity, significantly restricting its application in clinical stroke treatments.

The research group designed and constructed a ROS-responsive polyfingolimod nanoprodrug coated with neutrophil membranes for targeted therapy of ischemic stroke reperfusion injury. On one hand, the neutrophil membrane-coated polyprodrug nanocarriers can effectively cross the blood-brain barrier due to their inherent inflammatory tropism, enhancing the drug delivery efficiency to the stroke site. On the other hand, the ROS responsiveness of the nanoparticles ensures selective drug release at the stroke site, thereby reducing the side effects of fingolimod after intravenous administration. The study showed that compared to free fingolimod,





the polyfingolimod nanoprodrug significantly improves cognitive and motor abilities of stroke mice while exhibiting markedly reduced cardiac toxicity and infection risk. Single-cell RNA sequencing analysis revealed that the polyfingolimod nanoprodrug can achieve anti-inflammatory effects by regulating the expression of the key microglial gene Cebpb at the inflammation site. This research not only provides a new platform for the application of fingolimod in stroke therapy, but also offers new insights into the use of polyprodrug nanomedicines in disease treatment and diagnosis. ■

Paper Link: https://onlinelibrary.wiley.com/doi/10.1002/adma.202311803?af=R

A MOTILE NANOMACHINE FOR ATP SYNTHESIS AND DIRECTED TRANSPORT

The team led by Professors Qiang He and Yingjie Wu, from the school of life science and medicine Harbin Institute of Technology, has made important research progress in the field of bioinspired swimming nano-robots. The research results were published in the *Journal of the American Chemical Society* entitled **Rotary FoF1-ATP Synthase-Driven Flasklike Pentosan Colloidal Motors with ATP Synthesis and Storage**. This study uses the nanoscale rotary biological molecular motor ATP synthase as the power component, successfully realizing that sub-micrometer-scaled bioinspired swimming nanorobots perform the bioenergy currency ATP synthesis, storage and directional transport, which has broad application prospects in the field of active targeted energy metabolism regulation therapy and other biomedical fields.

In biological systems, directional migration and the supply of the bioenergy currency ATP are crucial for many physiological and pathological processes. Scientists have developed various enzyme-driven swimming nanorobots with positively or negatively chemotactic abilities to perform various biomedical tasks. However, swimming nanorobots powered by natural biological enzymes are sensitive to the surrounding ionic environment, and there are practical problems in achieving efficient actuation under physiological conditions. As the smallest rotary biological molecular motor in nature, FoF1-ATP synthase has the advantages of high efficiency and safety in energy conversion, and operates well under physiological conditions. Therefore, developing a bioinspired swimming nanorobot based on FoF1-ATP synthase as the power unit, improving its self-propulsion performance and biomedical application functions under physiological conditions, will provide an important theoretical basis for swimming nanorobots to perform precise diagnostic and therapeutic tasks.

The research team used FoF1-ATP synthase as the power unit and successfully prepared a streamlined, sub-micrometer flasklike swimming nanorobot. Experimental data analysis and theoretical simulation show that based on the advantages and functions of FoF1-ATP synthase, external protons diffuse radially through the bottle cavity and synergistically drive the phosphorylation reaction of FoF1-ATP synthase, which can use the widely existing ADP and inorganic phosphate (Pi) in the biological body to synthesize the bioenergy ATP, realizing biologically safe energy conversion and autonomous mobility, while exhibiting a relatively high ATP

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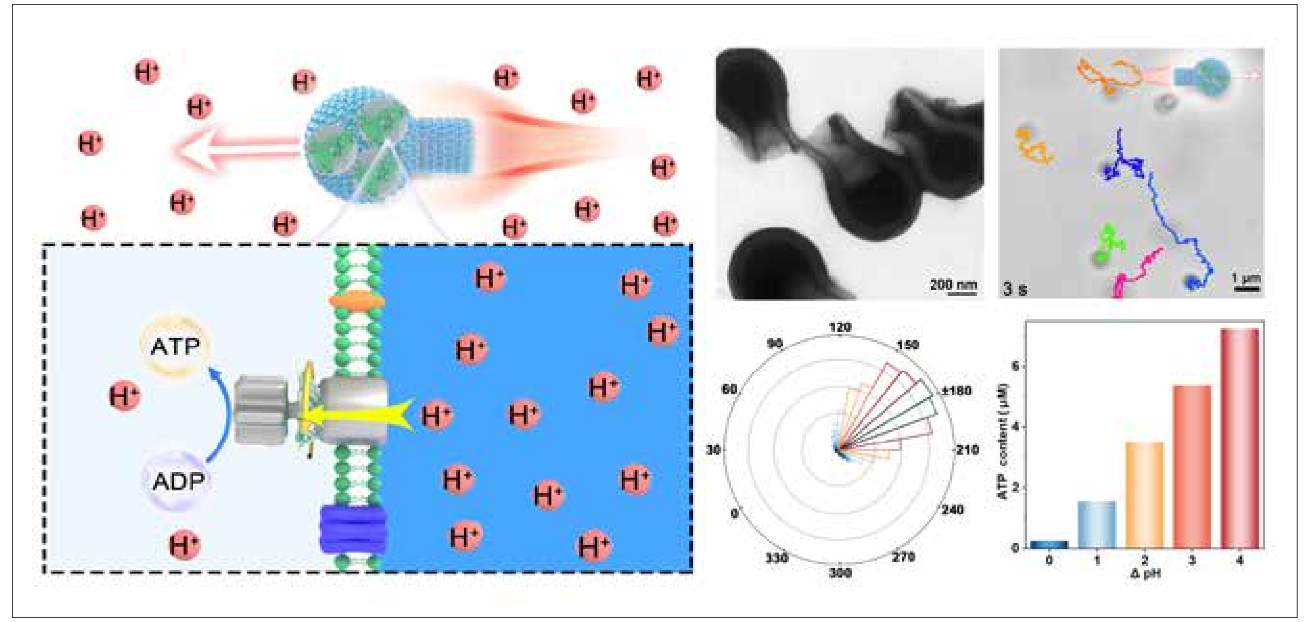

synthesis and storage capacity. In an external proton gradient environment, the swimming nanorobot exhibits a clear negatively chemotactic behavior, i.e., it migrates directionally along the proton gradient towards the direction away from the proton source. Furthermore, when the external medium contains chemical signals that induce ATP release, the swimming nanorobot can release the stored ATP as needed. This swimming nano-robot that integrates the functions of ATP synthesis, storage and targeted delivery provides a new approach for the precise treatment of diseases related to ATP imbalance. ■

Paper Link: https://pubs.acs.org/doi/full/10.1021/jacs.4c00334

Research & Academia
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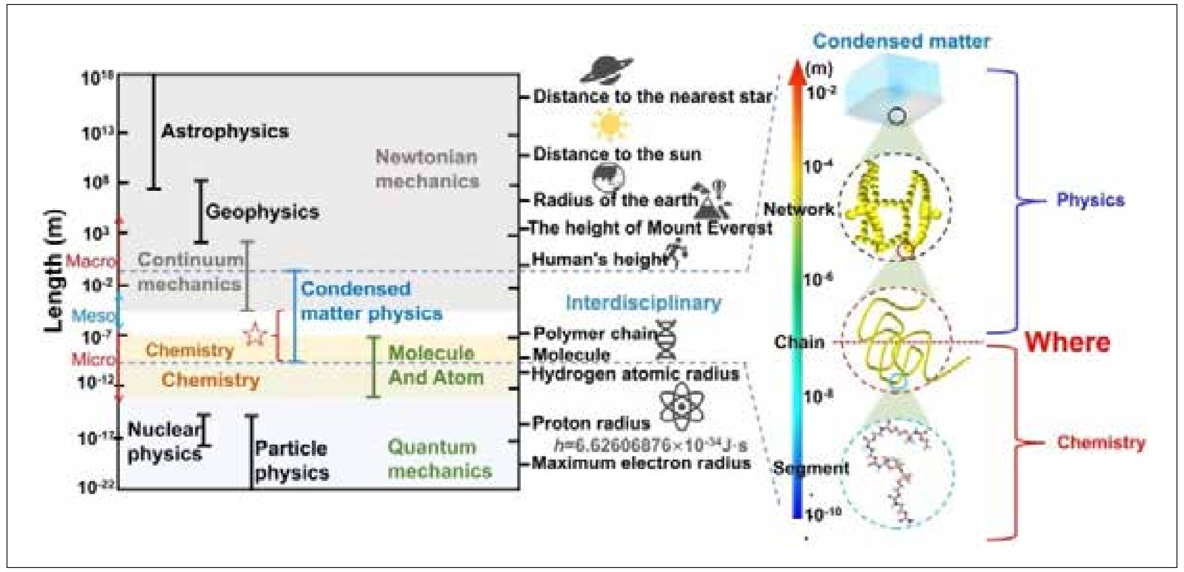
125 QUESTIONS: WHAT DON'T WE KNOW? THE NATURE OF GLASSY MATTER AND CAN THE LAWS OF PHYSICS BE UNIFIED?

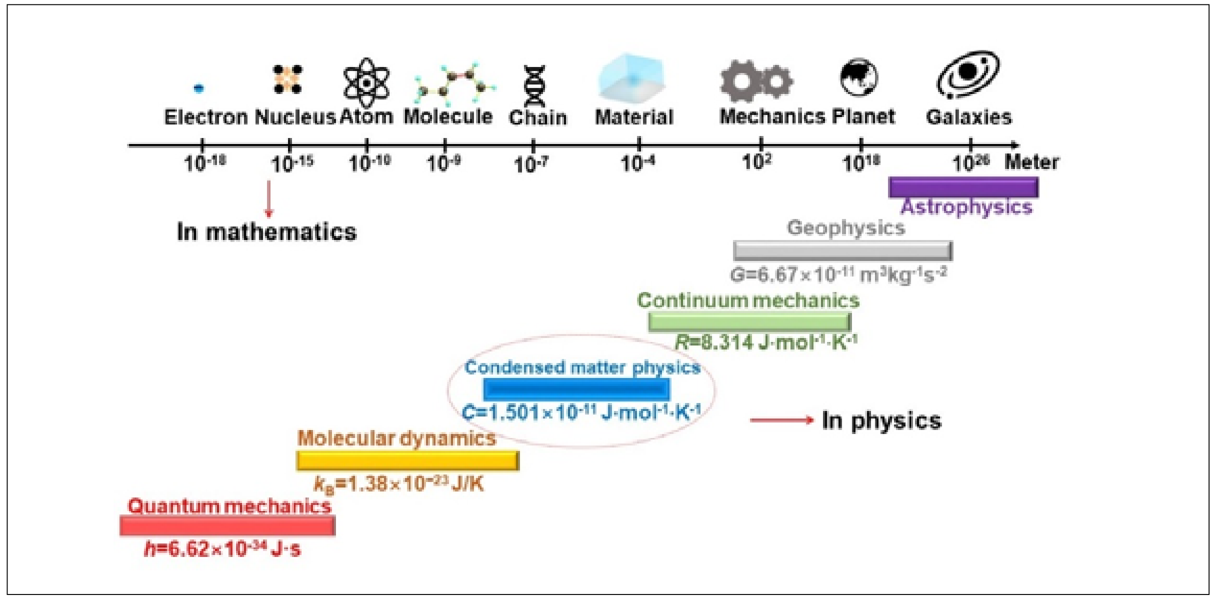
Professor Haibao Lu from Harbin Institute of Technology has published an article entitled with “When Physics Meets Chemistry at The Dynamic Glass Transition” in the journal Reports on Progress in Physics. This study aims on the nature of glassy matter and the glass transition, and provides a fundamental approach to understand the “The Nature of Glassy Matter” and “Can The Laws of Physics Be Unified?”, which have been highlighted as the greatest scientific conundrums for the next quarter century by Science journal in 2005.



This research provides a partial foundation and scaling mechanics for these two major scientific challenges of whether physical laws can be unified and what the nature of glassy matter is. The editor of Reports on Progress in Physics commented that any discussion of this nature has to acknowledge Maxwell’s achievements and relate the challenge of linking them with Newton’s work on gravity.

Professor Lu discovered that the glass transition was originated from the cross-scaled mechanics (scaling law) between molecular with condensed matter scales. He proposed a thermodynamic order-to-disorder free-energy equation for microphase separation to formulate the dynamic equilibria and fluctuations, and 19.5 monomers undergoes microphase separation at the critical equilibrium state of glass transition.

Professor Lu stated a concept of molecular entanglement for cooperative relaxation, established an extended Adam-Gibbs domain size equation, and calculated that the number of molecular entanglements was $e+1\approx3.718$ at the glass transition. The entropy increase



principle in glass transition between molecular with condensed matter scales had been explored.

Based on Einstein's mass-energy equation, Professor Lu established a spatiotemporal correlation equation of the dual function of energy and volume, solved the Free Volume Hypothesis, and established a condensed matter constant equation, calculating the condensed matter constant to be about 1.501×10^-11 J·mol^-1·K^-1, which was similar to the Boltzmann constant (k_B for molecular dynamics) and gas constant (*R* for macroscopic scale) through a fractal iteration equation.

Based on the above-mentioned results, Professor Lu claimed the unification of physical laws between molecular physics (chemical constraint for molecule motion) with condensed matter physics (physical constraint for macromolecule motion), discussed on the division of parallel physical world into molecular, condensed matter and macroscopic scales, provided a proof of whether physical laws can be unified, and found out the condensed matter constant for condensed matter scale.■

Paper Link: https://iopscience.iop.org/article/10.1088/1361-6633/ad2b9c

HIT RESEARCH GROUP UNCOVERS OLEIC ACID AS A NATURAL LIGAND FOR ORPHAN RECEPTOR (GPR_3)

The research team led by Professor Yuanzheng He from Center for Life Sciences of Harbin Institute of Technology, in collaboration with the research teams of Professor Zheng Chen and Professor Yu Xia from Tsinghua University, made significant progress in the structural research of the orphan receptor (GPR3). The research results were published in the journal of *Cell Research* under the title **Identification of Oleic Acid as an Endogenous Ligand of GPR3**. The research results revealed the natural ligand of GPR3, its self-activation mechanism, and its heat-generating mechanism induced by cold stimulation, providing new insights for the treatment of related metabolic diseases.

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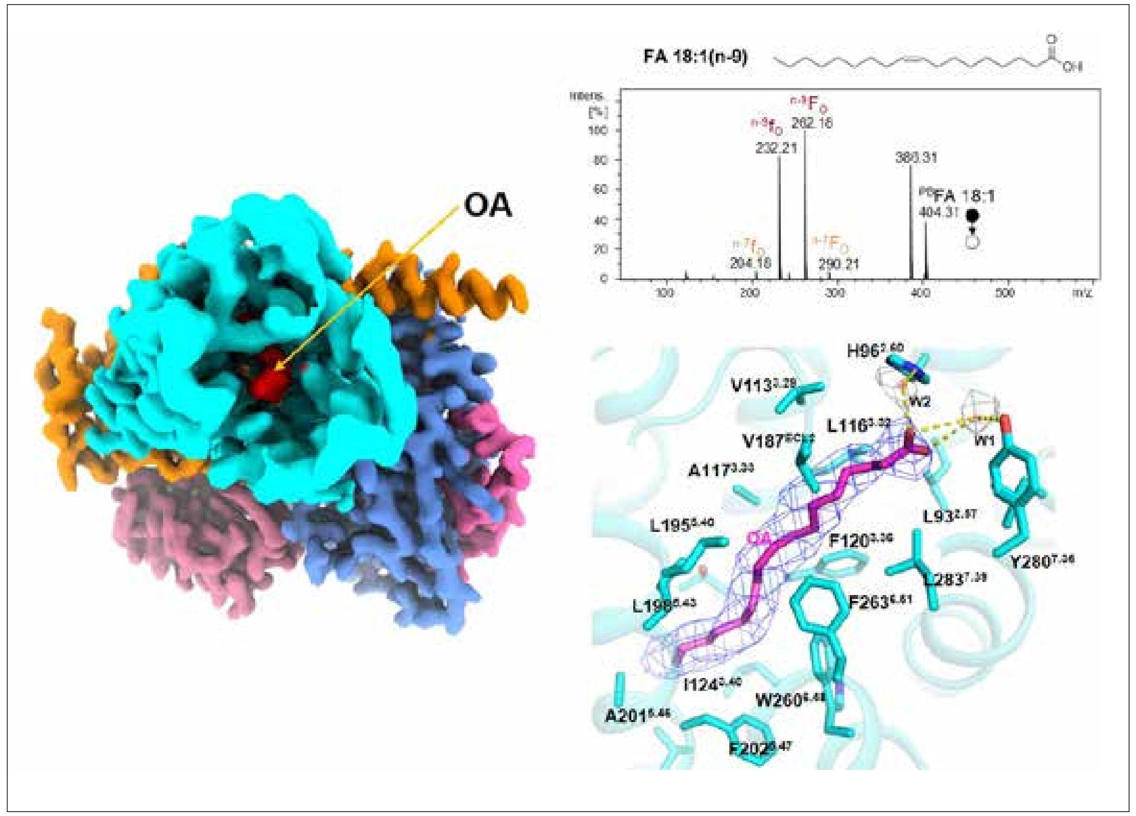
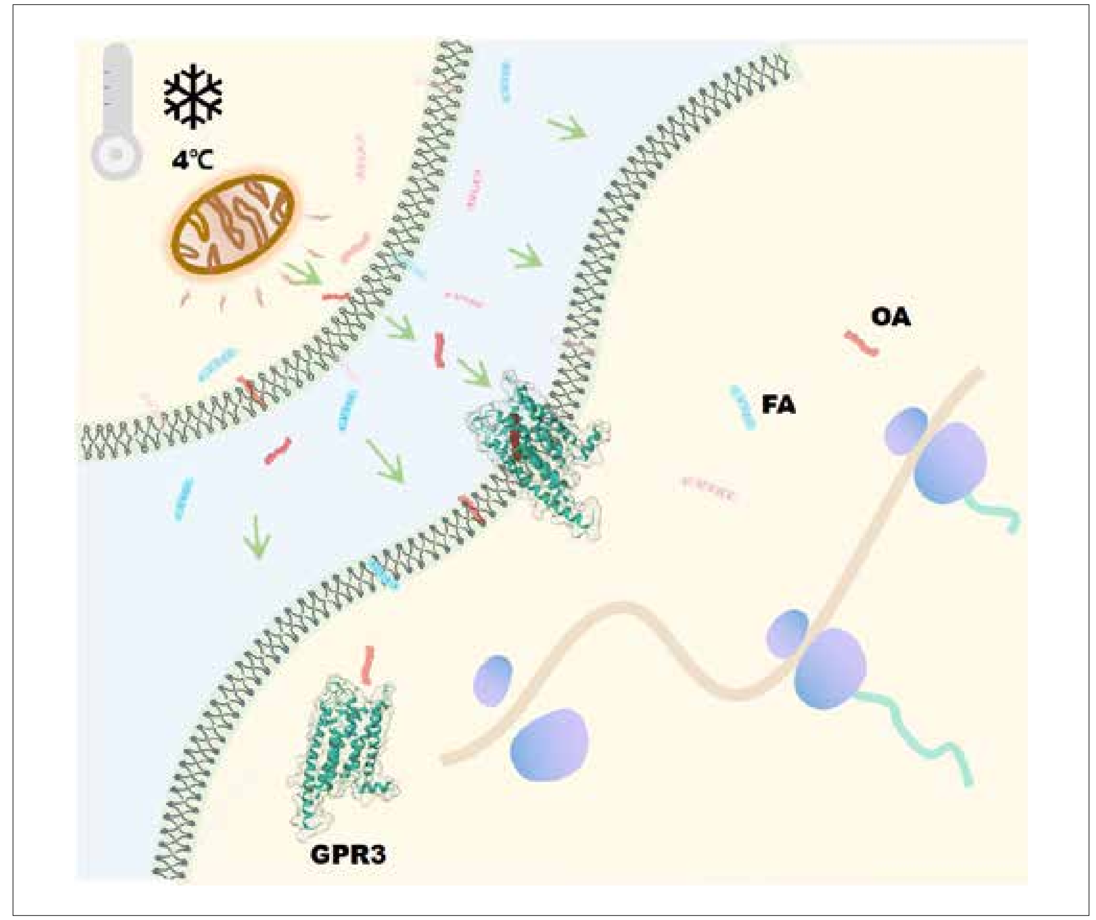


GPR3, as an orphan receptor in the class A G protein-coupled receptor family, has a relatively high constitutive activity and plays a key role in the nervous system and metabolism. In the nervous system, GPR3 can regulate emotions, participate in neuropathic pain and addiction processes, and is closely related to Alzheimer's disease (dementia). In terms of metabolism, cold stimulation can induce high expression of GPR3 to drive thermogenesis, so it has the potential to treat metabolic diseases including obesity and diabetes, but its structural information and endogenous ligands were not clear.

The research team used cryo-electron microscopy to analyze the complex structure of GPR3 and Gs protein at a global resolution of 2.79 angstroms. At the same time, in the structural analysis, they found electron density of lipid-like ligands in the ligand-binding pocket of GPR3, and identified this density as the oleic acid (OA) molecule through mass spectrometry analysis (Fig.1). Subsequent structural and functional analyses showed that the hydrophobic channel inside GPR3 connects the extracellular side of the receptor with the middle of the cell membrane, making the fatty acids in the cell



membrane easily bind to the receptor (Fig.1). Meanwhile, free fatty acids such as oleic acid, palmitic acid, and lauric acid can bind and activate GPR3, while lysophosphatidic acid cannot. Further animal experiments showed that cold stimulation can induce the secretion of OA in mice, thereby activating the Gs/cAMP/PKA signaling pathway in brown adipose tissue, while Gpr3 gene knockout mice did not respond to OA under cold stimulation. Based on this, the researchers proposed a "born to be activated and cold to enhance" model for the activation mechanism of GPR3 (Fig.2), providing a basis for understanding the activation of GPR3 and the heat generation mechanism under cold stimulation.■

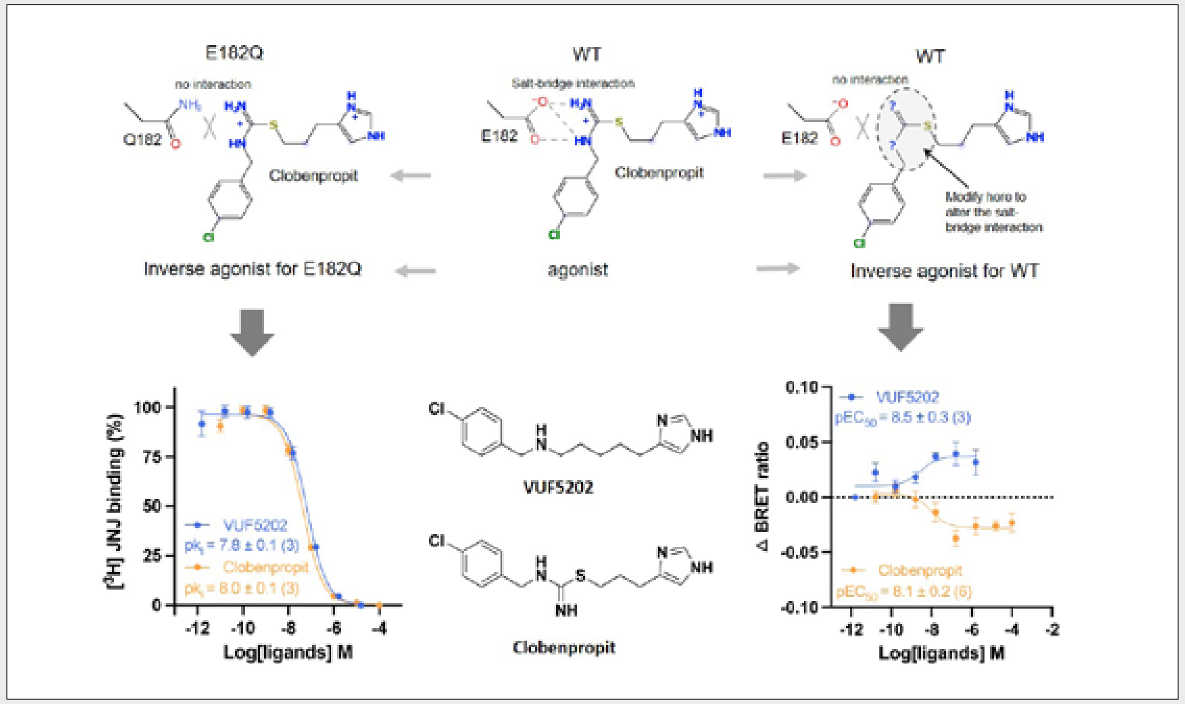
Paper Link: https://www.nature.com/articles/s41422-024-00932-5

RESEARCH FINDINGS FROM HARBIN INSTITUTE OF TECHNOLOGY PROVIDE INSIGHTS FOR DEVELOPING NOVEL ANTIHISTAMINE DRUGS

The research group led by Professor Yuanzheng He from Center for Life Sciences at Harbin Institute of Technology, in collaboration with Professor Rob Leurs and his team from Vrije University Amsterdam, published a paper in Nature Commun*ications* titled **Structural Basis of Ligand Recognition and Design of Antihistamines Targeting Histamine H4 Receptor**. This work provides an crucial theoretical foundation for the design of new antihistamine drugs targeting the histamine H4 receptor.

Histamine, as a biogenic amine, regulates downstream signaling pathways by binding to histamine receptors, thereby mediating various physiological activities. Histamine receptors belong to the superfamily of class A G protein-coupled receptors (GPCRs), with 4 subtypes (H1-H4 receptors). Recent studies on the physiological and pathological roles of histamine receptors, as well as the use of receptor antagonists in disease models, have revealed the great potential of histamine receptors in the treatment of allergic inflammation, neuropathic pain, and cancer. Currently, there are many clinically used antihistamine drugs targeting H1-H3 receptors, but the potential anti-inflammatory therapy of H4 receptor antagonists is still in clinical trials. Elucidating the structure of the H4 receptor and understanding its activation mechanism will provide an important theoretical basis for the design of histamine-related drugs.

The research group led by Professor Yuanzheng He unveiled the cryo-EM structures of the H4 receptor in complex with its natural ligand histamine, as well as with the synthetic agonists clobenpropit, VUF6884, and chlorpheniramine. These structures reveal the unique ligand binding mode of histamine to the H4 receptor. In the H1 receptor, the imidazole of histamine points towards transmembrane helices 3 and 5, and forms a key ionic interaction with the asparagine at position 198. In contrast, in the H4 receptor, the imidazole points towards



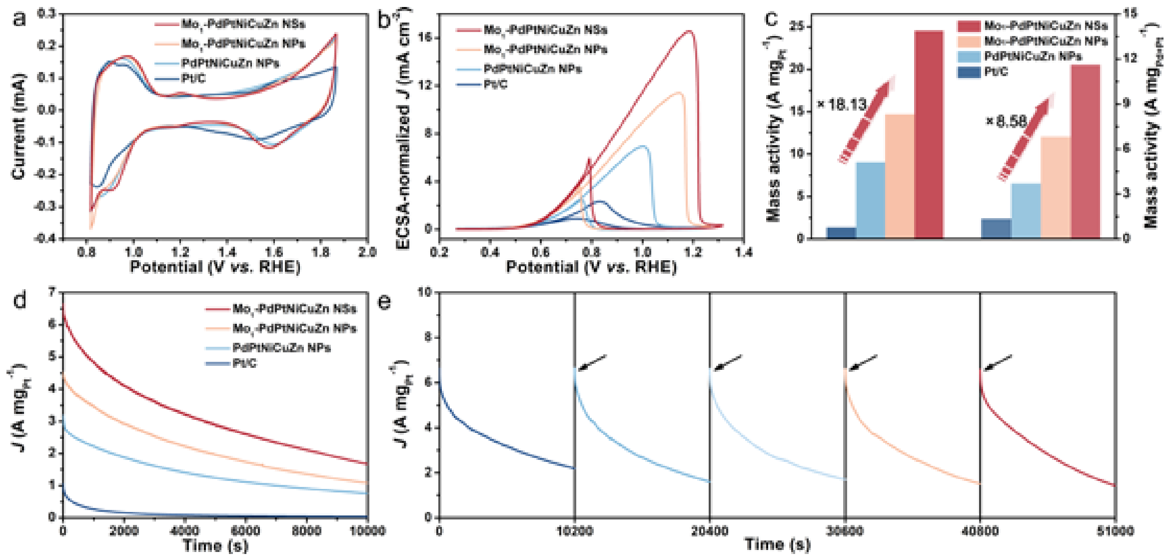
transmembrane helix 7 and forms π-electron cloud-positive electrostatic interactions with the phenylalanine at position 344, the tryptophan at position 348, and the lysine at position 319. Importantly, in the structure of the H4 receptor in complex with the agonist clobenpropit, two glutamate mutations at position 182 were found to convert the agonist clobenpropit into an inverse agonist. Based on this structural feature, Professor Yuanzheng He and Professor Rob Leurs' research groups collaborated to design and screen a novel H4 receptor inverse agonist VUF5202 with potential anti-inflammatory therapeutic applications. ■

Paper Link: https://www.nature.com/articles/s41422-024-00932-5

MODIFIED HIGH-ENTROPY ALLOY CATALYSTS TO ENHANCE ENERGY ELECTROCATALYSIS EFFICIENCY

Professor Yongsheng Yu from the School of Chemical Engineering and Technology, a member of the National Key Laboratory of Urban Water Resources and Water Environment, has collaborated with Professor Shaojun Guo's team from Peking University to achieve significant progress in the field of high-entropy alloy energy electrocatalysis.

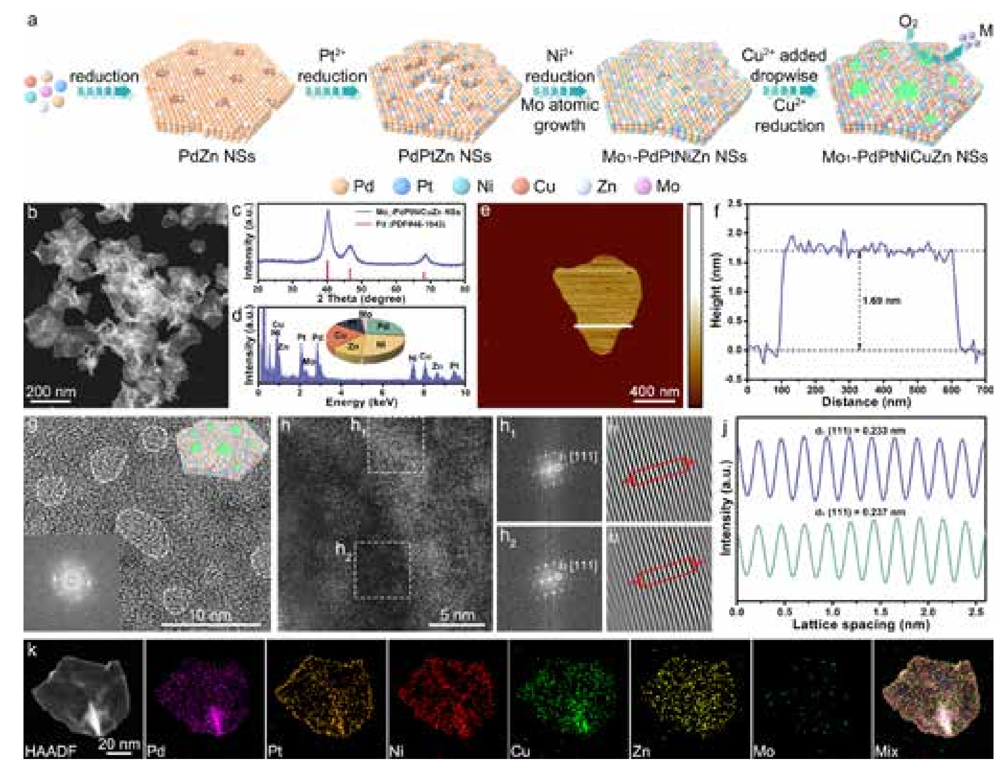
Their research, titled **Single-Atom Mo-Tailored High-Entropy-Alloy Ultrathin Nanosheets with Intrinsic Tensile Strain Enhance Electrocatalysis**, has been published in *Nature Communications*. This achievement enhances the electrocatalytic efficiency of methanol oxidation by altering the performance of high-entropy alloy electrocatalysts through single-atom doping and strain engineering.



Direct methanol fuel cells (DMFCs) are recognized as ideal power sources for portable electronic devices and electric vehicles due to their high energy conversion efficiency, environmental friendliness, and convenient transport. Platinum-based catalysts are commonly used for anodic methanol oxidation reaction (MOR); however, the high dosages of Pt-based catalysts and poor tolerance to CO adsorbates (CO_{ads}) (the notorious intermediate blamed for poisoning Pt active sites in MOR) severely hinder the large-scale commercialization of DMFCs. To improve catalyst efficiency, it would be beneficial to further promote the oxidation of CO intermediates or switch the reaction to CO-free pathway.

Research has shown that high-entropy alloys (HEAs) are promising materials for the freedom from CO poisoning and improving MOR performance because of their robust capacity for isolating Pt atoms and their expansive and modulable compositional space. Despite significant advancements in the design of high-entropy alloys in recent years, precisely designing and optimizing HEAs at the atomic level to improve MOR activity, CO tolerance, and stability remains a substantial challenge.

In response to this, the team synthesized oxophilic molybdenum single-atom modified platinum-based high-entropy alloy ultrathin nanosheets, significantly enhancing the electrooxidation of MOR. The representative



Mo_1-PdPtNiCuZn single-atom high-entropy alloy nanosheet catalyst exhibited excellent mass activity (24.55 A per milligram of platinum and 11.62 A per milligram of platinum plus palladium) and long-term stability. The team investigated the mechanism behind the enhanced MOR performance of the Mo_1-PdPtNiCuZn single-atom high-entropy alloy nanosheet catalyst through *in-situ* spectroscopy and theoretical calculations. The results indicated that the oxophilic molybdenum single atoms and tensile strain further adjusted the electronic structure of the isolated platinum active sites in the high-entropy alloy hosts, optimizing the adsorption behavior of key reaction intermediates, thereby enhancing formate-dominated MOR electrocatalysis. This research establishes a new paradigm for single-atom-modified high-entropy alloys, advancing the design of atomically precise catalytic sites and paving the way for the development of CO-tolerant fuel cell electrocatalysts.

Paper Link: https://www.nature.com/articles/s41467-024-45874-z

HIT RESEARCH TEAM PROPOSED INTERFACE ELECTRONIC COUPLING MECHANISM TO ENHANCE CATALYST ACTIVITY AND STABILITY

The research group of Professor Zhenbo Wang from the School of Chemical Engineering and Technology at Harbin Institute of Technology has made significant advancements in the field of bifunctional oxygen electrocatalysts. Their research, titled **Engineering Co-N-Cr Cross-Interfacial Electron Bridges to Break Activity-Stability Trade-Off for Superdurable Bifunctional Single Atom Oxygen Electrocatalysts**, has been published in *Angewandte Chemie*. This achievement is expected to provide new insights for the design and application of next-generation cathode catalysts in hydrogen fuel cells and metal-air batteries.

Hydrogen fuel cells and metal-air batteries are crucial for achieving the “dual carbon” goals due to their clean and efficient characteristics. However, the stability of cathode catalysts under high currents and prolonged operation conditions poses a significant barrier to their large-scale development.

To improve the long-cycle durability of cathode catalysts, Professor Zhenbo Wang proposed an interface electronic coupling mechanism. They constructed Co-N-Cr cross-interfacial electron bridges (CIEBs) via the interfacial electronic coupling between Cr_2O_3 and Co-N-C, breaking the activity-stability trade-off. The partially occupied Cr 3d-orbitals of Co-N-Cr CIEBs induce the electron rearrangement of CoN_4 sites, boosting the adsorption of intermediates. Damjanovic kinetic analysis indicates the

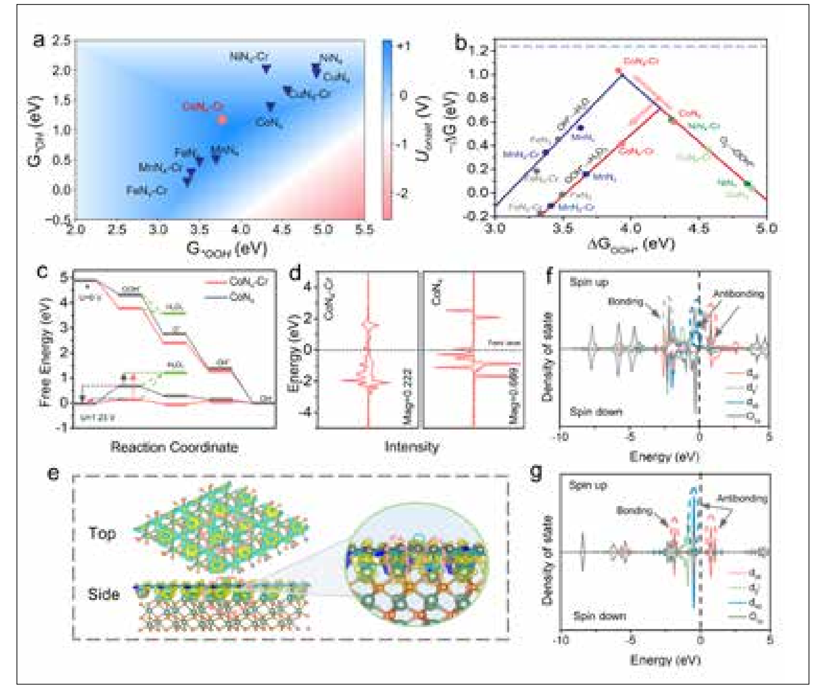


Figure 1. Theoretical predictions for designing cross-interfacial electron bridges (CIEBs) a) U_{onset} volcano map as a function of OH and OOH based on the different model. b) Calculated ORR catalytic activity volcano via two-electron (red line) and four-electron ORR (blue line). c) ORR free energy diagrams of CoN_4-Cr and CoN_4 at different electrode potentials. d) PDOS of Co for CoN_4-Cr and CoCN. e) The differential charge density map of CoN_4-Cr model. PDOS of Co 3d and O 2p orbital for f) CoN_4-Cr and g) CoN_4.

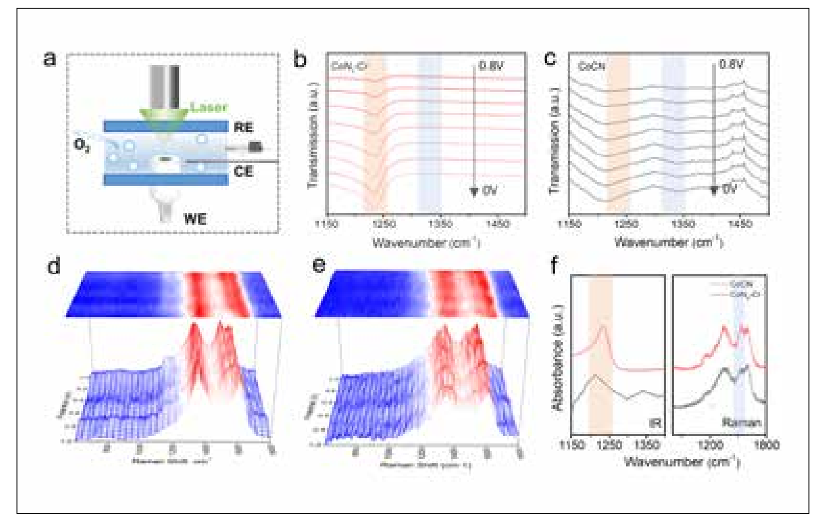


Figure 2. In-situ characterization elucidates the reaction mechanism. a) In situ ATR-SEIRAS device schematic. ATR-SEIRAS spectra of b) CoN_4-Cr and c) CoCN. 3D in situ Raman spectroscopy of d) CoN_4-Cr and e) CoCN. f) The comparison of ATR-SEIRAS and Raman signals for CoN_4-Cr and CoCN at 0 V.

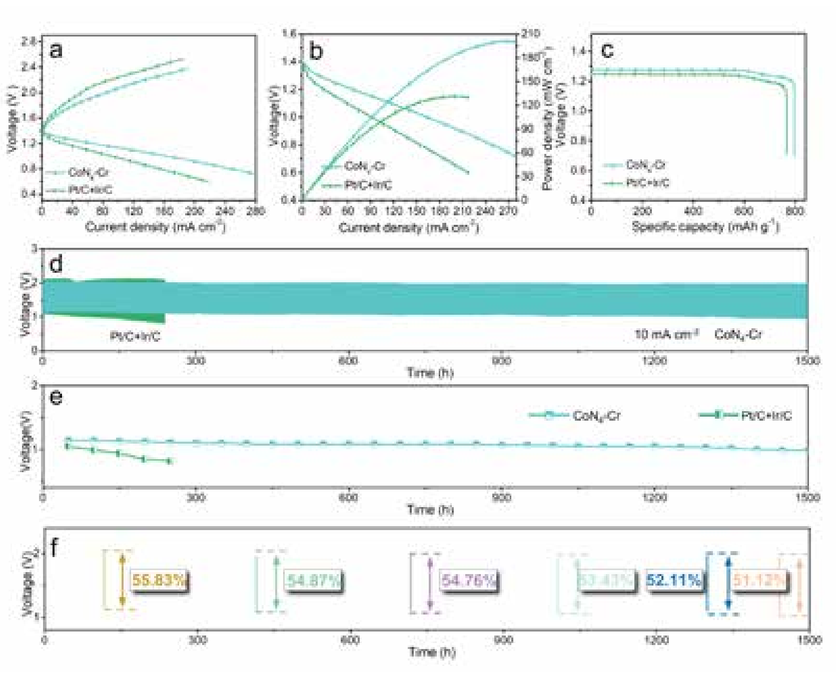
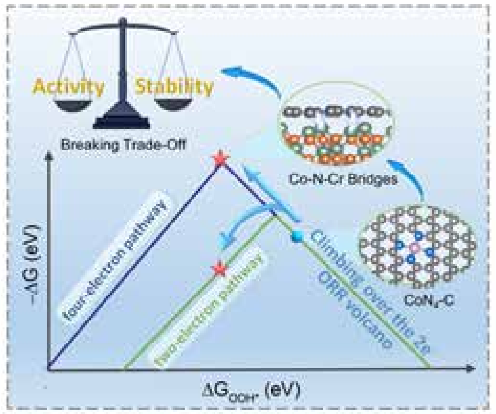


Figure 3. Electrochemical performances of rechargeable Zn-air battery. a-b) The polarization and converted power density curves. c) Specific capacity test during discharge for ZAB-CoN$_4$-Cr and ZAB-Pt/C+Ir/C. d) Galvanostatic discharge/charge cycling performance of ZAB-CoN$_4$-Cr and ZAB-Pt/C+Ir/C at a current density of 10 mA cm^{-2}. e) The corresponding discharge voltage stability graphs. f) Voltage efficiency graphs of CoN$_4$-Cr at 150, 450, 750, 1050, 1350, and 1500 h during the cycling test.

Co-N-Cr CIEBs suppress the two-electron ORR process and approach the apex of Sabatier volcano plot for four-electron pathway simultaneously. The Co-N-Cr CIEBs demonstrate impressive activity and breakthrough durability including cycling performance over 1500 h for Zn-air battery. The hybrid interfacial configuration and understanding of the electronic coupling mechanism reported here could shed new light on the design of high-durability catalysts.



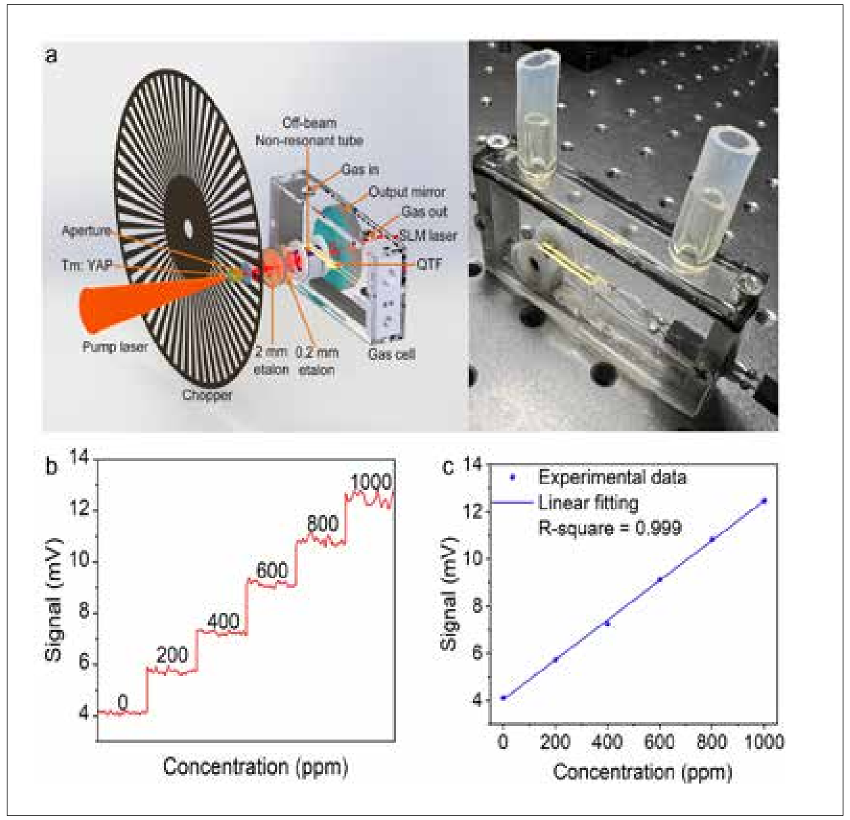
Graphical Abstract

Paper Link: https://doi.org/10.1002/anie.202400577

PHOTOACOUSTIC SPECTROSCOPY (PAS) SENSOR SYSTEMS CAN ACHIEVE ULTRA-HIGHLY SENSITIVE DETECTION OF DUAL-COMPONENT GASES

The research team led by Professor Yufei Ma from the School of Astronautics at Harbin Institute of Technology has realized ultra-highly sensitive dual-component gases detection based on photoacoustic spectroscopy using a new type excitation source. The related research results were published in the scientific journal of *Light: Science & Applications*, with the title of **Ultra-Highly Sensitive Dual Gases Detection Based on Photoacoustic Spectroscopy by Exploiting A Long-Wave, High-Power, Wide-Tunable, Single-Longitudinal-Mode Solid-State Laser**.

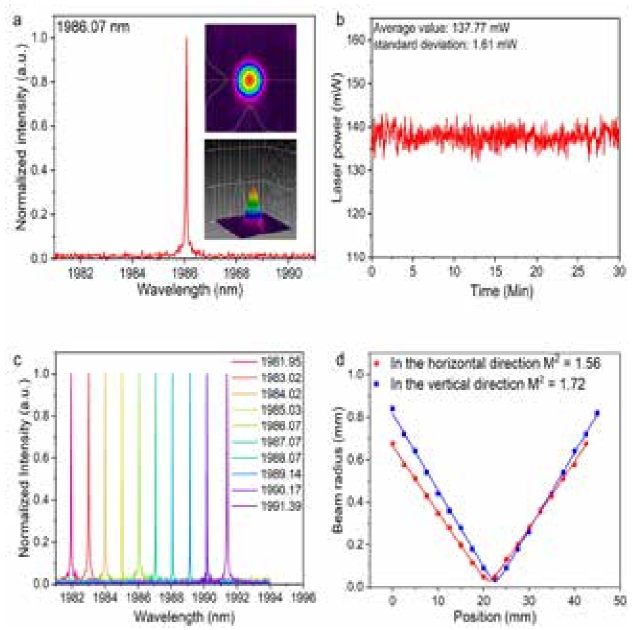
Photoacoustic spectroscopy (PAS) is a laser absorption spectroscopy-based gas



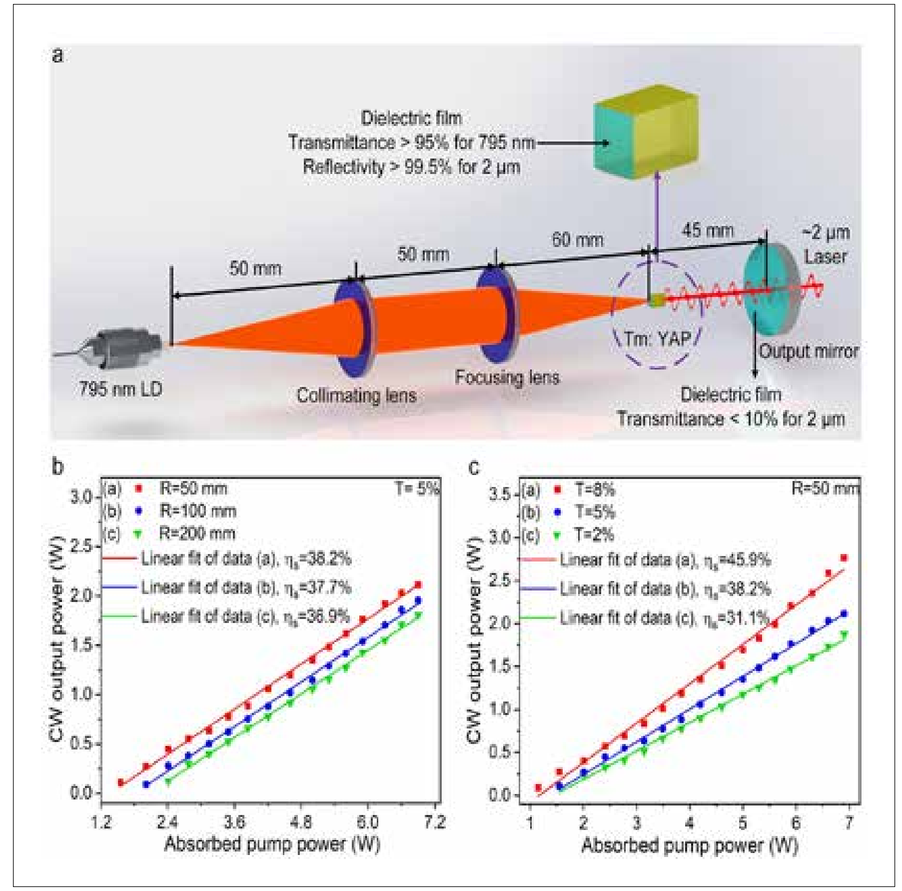
Intracavity QEPAS sensor system and measurement results.jpg

sensing technology that has the advantages of good gas selectivity, high detection sensitivity, and fast response speed. It has important application value in fields such as environmental monitoring, fire warning, and medical diagnosis. The excitation source, as the core component of the sensor system, plays a decisive role in the detection performance of the system. To achieve high-sensitivity detection of multi-component gases, laser absorption spectroscopy gas sensing technology urgently needs an ideal excitation source with long emission wavelength, high output power, wide tuning range, and good beam quality.

The research team led by Professor Yufei Ma started from the core component of the sensor system - the excitation source, and designed and built a tunable single-longitudinal-mode solid-state laser at 2-micron wavelength band. The output power of the single-longitudinal-mode laser is about 140 milliwatts, and it has a wide wavelength tuning range of 9.44 nanometers. Based on this, they designed photoacoustic spectroscopy sensor systems and realized high-sensitivity detection of water molecules and ammonia dual-component gases. In addition, the research team utilized the openness of the solid-state laser resonant cavity and used a novel low-frequency quartz tuning fork as the detection element to design an intracavity quartz-enhanced photoacoustic spectroscopy sensor system. By placing the tuning fork detection unit inside the laser resonant cavity, the system integration is improved while utilizing the high power density in the cavity. Compared with the common external cavity systems, the gas detection sensitivity is increased by up to 5.5 times. According to the concentration measurement results, the systems have excellent concentration linear response. ■



Output characteristics of single-longitudinal-mode laser.jpg



Output characteristics of solid-state laser under free operation conditions.jpg

Paper Link: https://doi.org/10.1038/s41377-024-01459-5

A RESEARCH ON SOLAR SYSTEM PLANETARY MAGNETOSPHERIC JET STREAMS

The research group of Professor Shen Chao from the School of Science at Harbin Institute of Technology has achieved significant results in the field of planetary magnetosheath jets, discovering the presence of magnetosheath jets in the outer solar system's giant planets. This discovery enhances our understanding of the potential impacts of magnetosheath jets on planetary magnetic fields, the characteristics of plasma shock waves in the solar system, plasma energy transport and conversion processes, and

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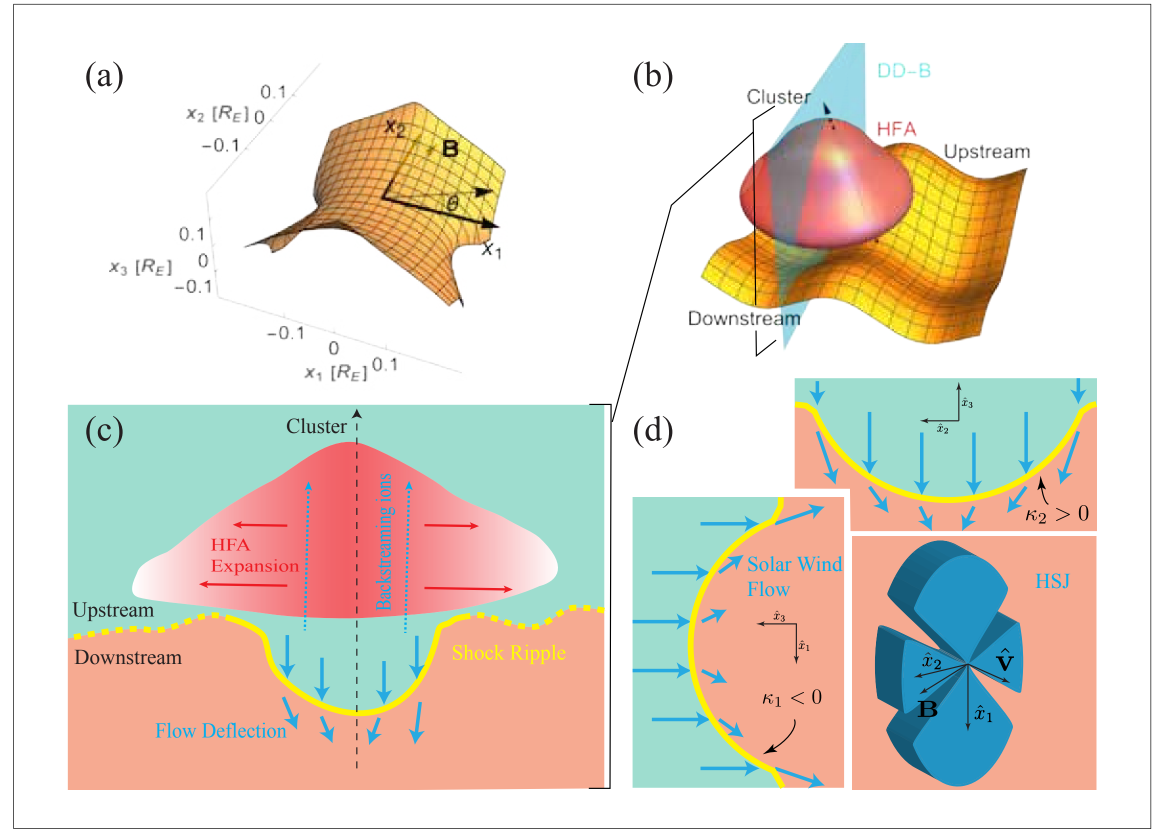
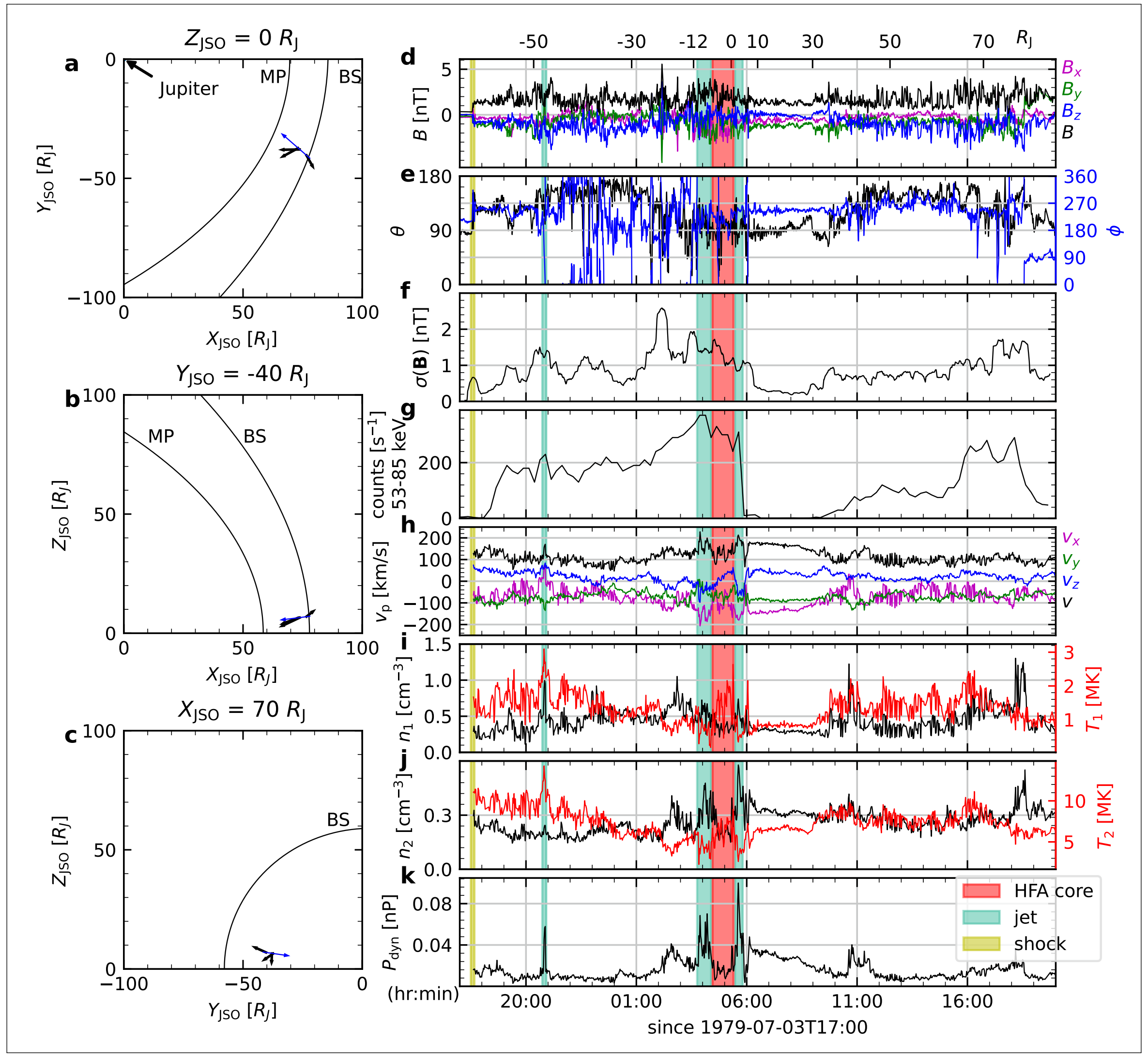


holds important application value for space weather event forecasting. The research findings have been published in *Geophysical Research Letters* and *Nature Communications*, and have been selected as a highlight article in *Nature Communications*.

The magnetosheath is an outer boundary layer formed by the interaction between a planet's magnetosphere and the solar wind, while magnetosheath jets are plasma flows within it where the kinetic energy greatly exceeds that of the surrounding plasma. Extensive exploration and analysis of Earth's space environment indicate that magnetosheath jets play important roles in energy transformation and transport from bow shocks and can contribute to the acceleration of charged particles. Earth's magnetosheath jets can drive magnetic reconnection processes at the magnetopause, facilitating the transport of solar wind material and energy into the magnetosphere, affecting the occurrence and evolution of geomagnetic storms, and generating space weather effects that influence spacecraft operations and space communications. Studying Earth's magnetosheath jets is crucial for understanding space weather events that

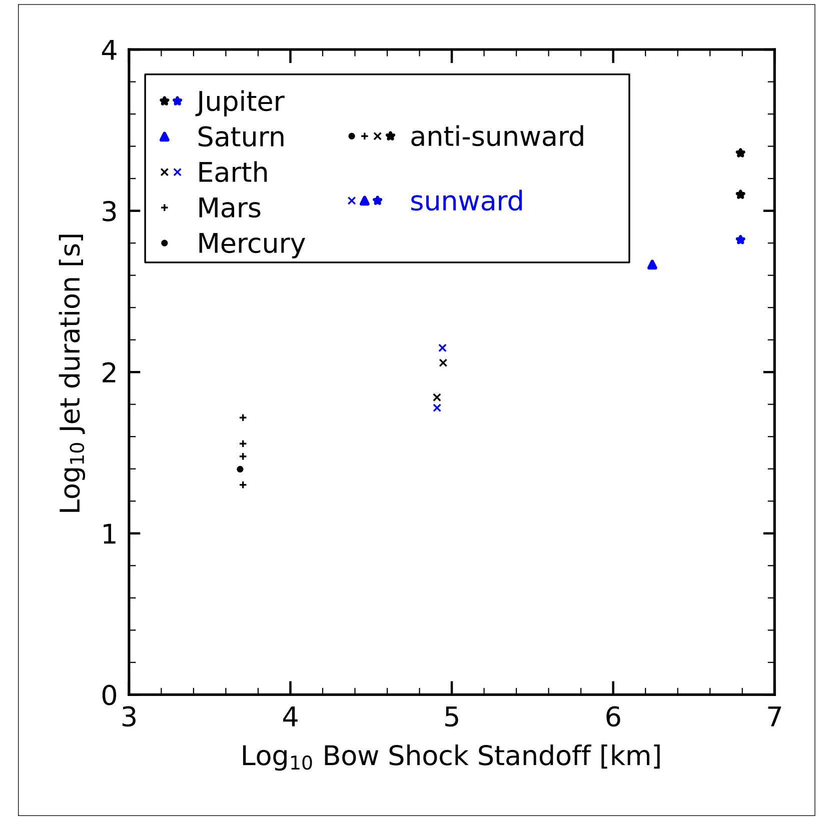


affect the operation of artificial satellites and communications. In recent years, evidence of jets has been found in the Martian magnetosheath, and some evidence supporting their existence has also been found in Mercury's magnetosphere. However, whether jets exist in the magnetosheath of other planets remains a contentious issue.

Professor Shen Chao's team utilized the recently proposed multi-point spatial detection method—normal vector field analysis—to analyze data from the Cluster spacecraft, discovering a new mechanism for the generation of magnetosheath jets: magnetosheath jets can arise from the interaction between bow shocks and solar wind

discontinuities (Fig.1). This new mechanism significantly enhances the understanding of jet formation in the academic community. This mechanism is not limited by the quasi-parallel or quasi-perpendicular nature of the shock wave and can lead to the generation of magnetosheath jets at all planetary bow shocks, suggesting that jets are prevalent in the magnetosheaths of solar system planets.

To further validate this new mechanism and its implications, Professor Shen Chao's team collaborated with scholars from Johns Hopkins University and Peking University to reanalyze data from Voyager 2's observations in Jupiter's magnetosheath, discovering three jets (Fig.2). One jet moves toward the Sun (similar jets have not been found at any other planet, and its source requires further investigation), while the other two jets move toward Jupiter, and the latter two jets align with the expectations of the new mechanism. The team compared these newly discovered



jets with those previously found on Earth and Mars, noting that their spatial scales vary with the spatial scale of the bow shocks. Meanwhile, the team also analyzed data from the Cassini mission and found preliminary evidence of jets in Saturn's magnetosheath. They incorporated the potential Saturnian jets and those in Mercury's magnetosheath into the comparison and found that all jets conform to the trend of varying with the scale of the bow shocks (Fig.3), further confirming the universality of planetary magnetosheath jets in the solar system. This research represents a significant advancement in the field of planetary science and has important applications in space weather prediction.■

Paper Link: https://doi.org/10.1038/s41467-023-43942-4 https://doi.org/10.1029/2023GL103848

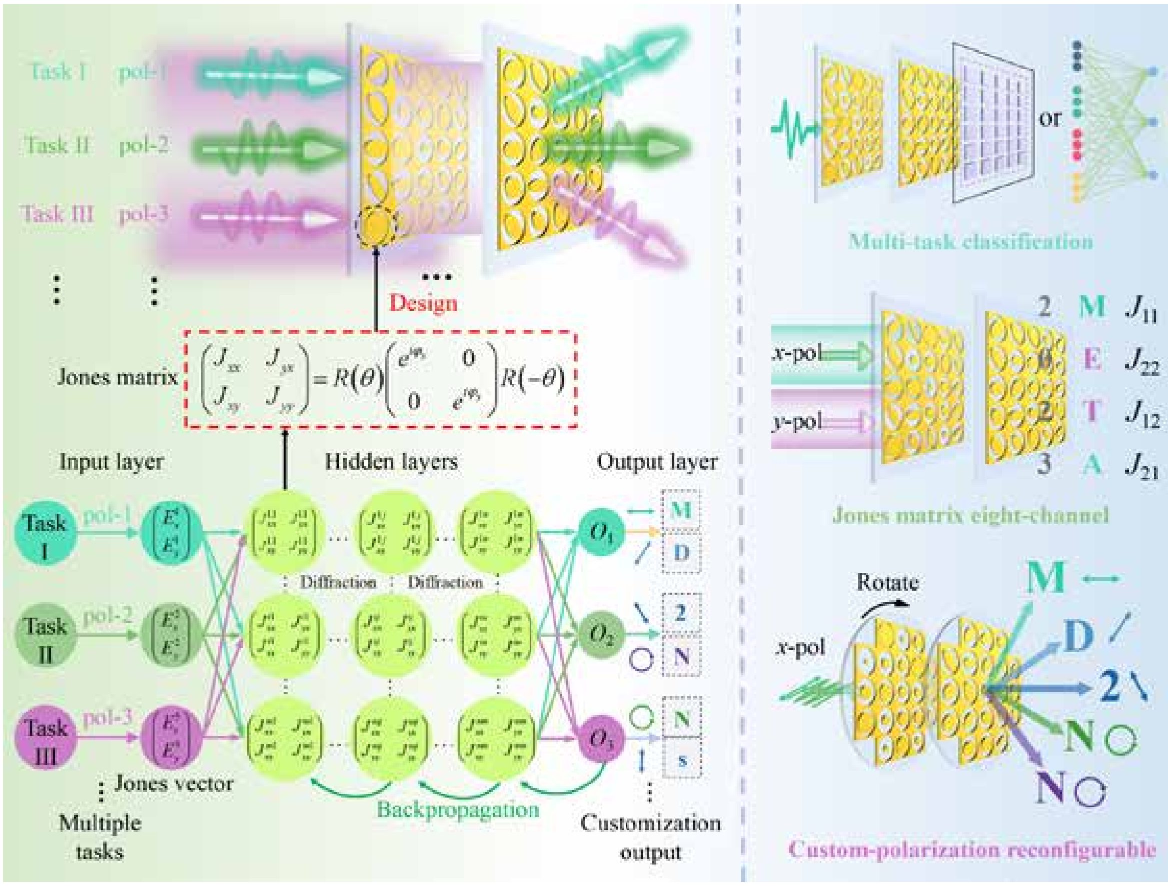
A NEW PROGRESS IN ALL-OPTICAL DEEP LEARNING

Professor Jiaran Qi's team from the School of Electronics and Information Engineering at Harbin Institute of Technology has made progress in the field of all-optical deep learning, proposing a matrix diffractive deep neural network architecture based on cascaded meta-surfaces. The research results, titled **Matrix Diffractive Deep Neural Networks Merging Polarization into Meta-Devices**, have been published in the journal *Laser & Photonics Reviews*, and are expected to find applications in fields such as machine vision, autonomous driving, smart healthcare, and the Internet of Things. The paper has also been selected as the front cover of this issue.

The all-optical diffractive deep neural network framework can design meta-surface devices with high parallelism and processing speed. However, it cannot directly utilize the polarization information of electromagnetic or optical waves, making it challenging to further expand channels and achieve more compactly configured multiplexed all-optical network devices.

The team proposed a matrix diffractive deep neural network architecture (MD2NNs) based on cascaded meta-surfaces, directly integrating the Jones matrix as an optimization variable into the all-optical network, granting it greater design freedom and richer functionality. This has led to the realization of integrated sub-meta-devices with high optoelectronic task capacity, non-interleaved efficient devices for full parameter optimization of the Jones matrix, and customized polarization information encryption meta-devices. MD2NNs provide researchers with a new strategy for incorporating polarization into electromagnetic and optical field modulators, promising to advance all-optical networks toward multi-task integration and more advanced functional devices.

Based on this framework, the team first achieved integrated sub-meta-devices with high optoelectronic task capacity by encoding multiple classification tasks into specific polarization channels, allowing multiple machine learning tasks to be integrated into a single meta-device. This meta-device possesses strong task-bearing capacity and considerable classification performance, significantly enhancing the task capacity of optoelectronic networks while saving hardware costs. Additionally, the team used MD2NNs to design a two-layer spatially cascaded birefringent meta-surface, achieving non-interleaved efficient full parameter optimization of the Jones matrix. The periodicity of the meta-units used is only 0.35 times the working wavelength, providing higher spatial resolution compared to traditional methods while maintaining the original



sub-wavelength characteristics and smaller relative aperture size of the meta-device. Meanwhile, the transmission energy is primarily concentrated in the 0th-order diffraction channel, eliminating the need for complex configurations for image enhancement using oblique incidence and oblique emission, resulting in higher holographic efficiency and more compact device configurations. Finally, the team designed a customized polarization information encryption meta-device using MD2NNs. This device consists of two layers of meta-surfaces, namely a pure phase and a birefringent meta-surface. By rotating or replacing the pure phase meta-surface, multi-channel, low crosstalk, customized polarization information encryption transmission can be achieved.■

Paper link: https://onlinelibrary.wiley.com/toc/18638899/2024/18/2

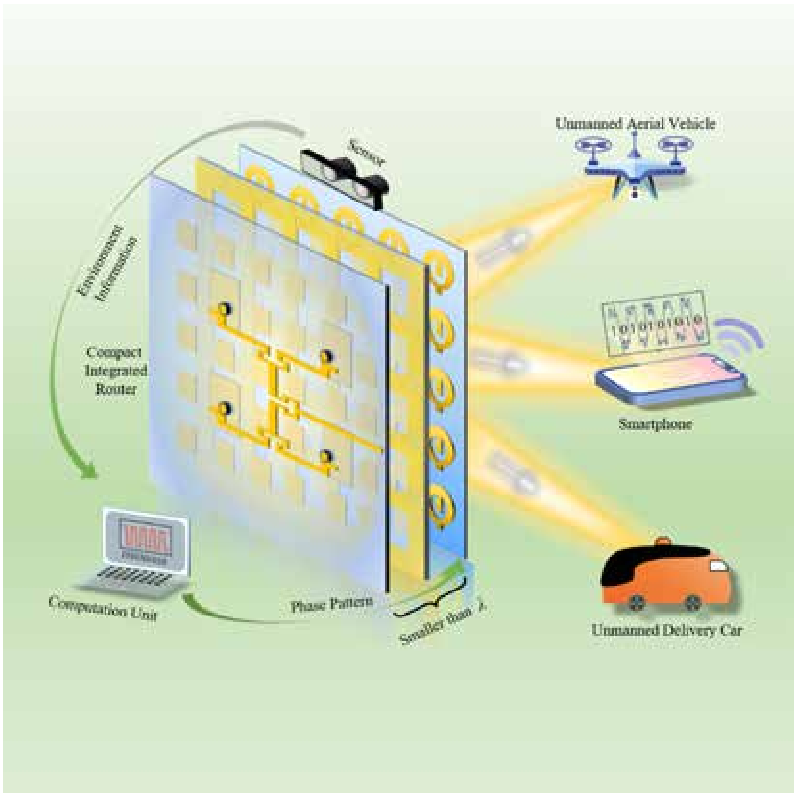
Research & Academia
HIT TIMES 2024

COMPACT WIRELESS POWER TRANSFER FRAMEWORK FOR EFFICIENT ENERGY TRANSMISSION

Professor Jiaran Qi's team, at School of Electronics and Information Engineering, Harbin Institute of Technology,, has made new advancements in the field of microwave wireless power transfer by developing a compact framework. Their research, titled **Intelligent Wireless Power Transfer via a 2-bit Compact Reconfigurable Transmissive-Metasurface-Based Router**, has been published in *Nature Communications*. Benefiting from advantages such as low cost and compactness, this framework is expected to promote the application of related devices based on metasurfaces in various fields, including smart homes, implantable medical devices, industrial robots, transportation, and space applications.

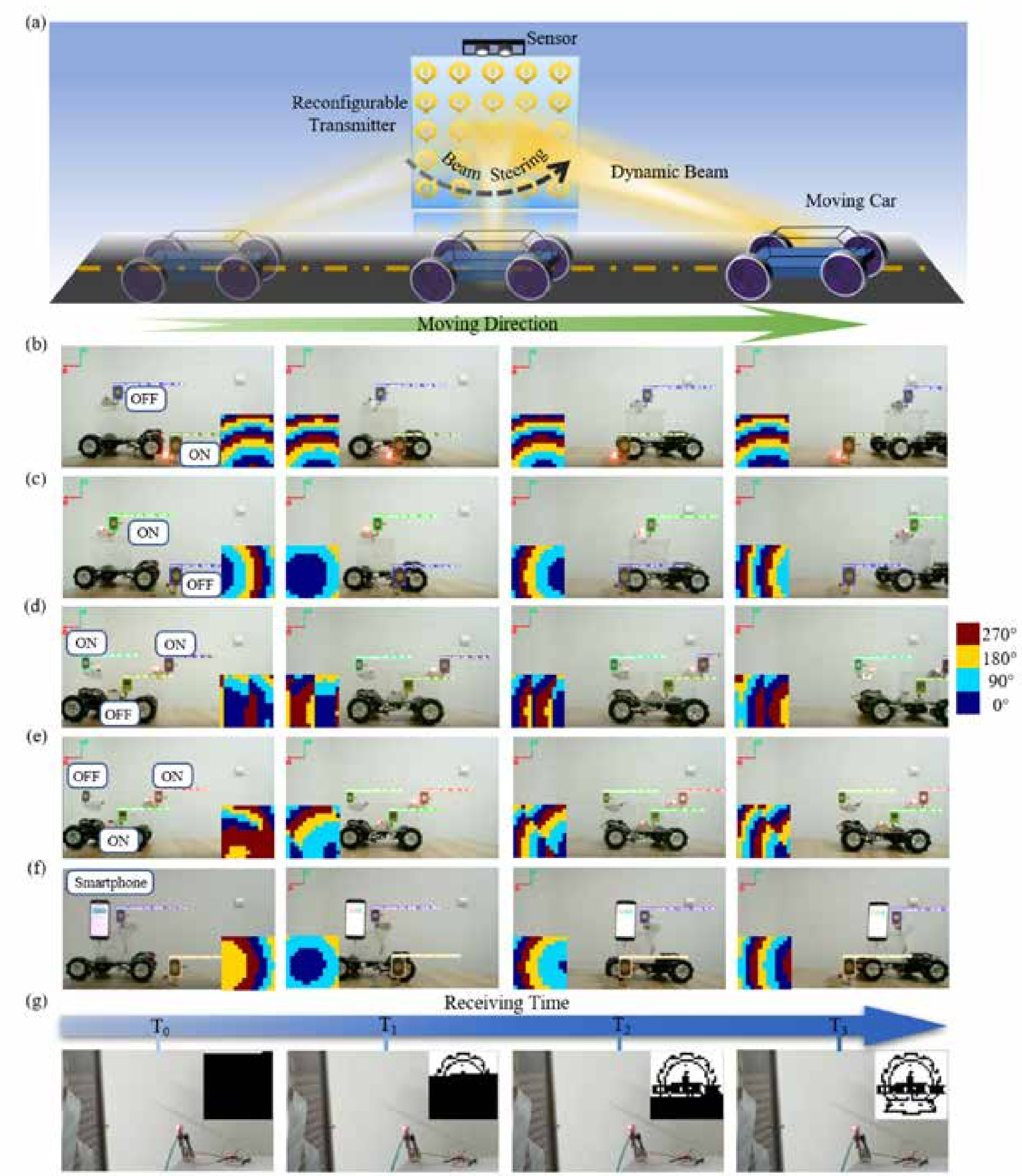
The team demonstrated the use of this wireless power transmitter to charge multiple everyday devices, such as LED lights, mobile phones, and power banks. They also showcased simultaneous wireless information and power transfer demonstrations using the transmitter, fully exhibiting the application potential of this wireless power transfer framework.

The team proposed a compact wireless power transfer framework based on reconfigurable transmissive metasurfaces. The core components of this framework include a plane-wave feeder and a 2-bit phase-reconfigurable transmissive



metasurface, together forming a multi-beam reconfigurable wireless power transmitter. This transmitter has a sub-wavelength profile (0.8 wavelengths), with an overall size comparable to that of a 27-inch LCD display. By integrating a deep learning-driven environmental sensor, the wireless power transmitter can detect and locate multiple moving devices and simultaneously transmit wireless power and information to them. The plane-wave feeder generates a nearly plane wave-like uniform wavefront in the near-field region, thereby exciting the metasurface, reducing the system profile to a sub-wavelength scale, which is an order of magnitude smaller than current mainstream excitation schemes.

The 2-bit reconfigurable transmissive metasurface consists of 169 unit-cells, enabling precise control of the wavefront phase through a programmable space-time modulation scheme. The combination of the near-field plane-wave feeder and the reconfigurable transmissive metasurface forms a wireless power transmitter capable of wirelessly delivering power to multiple targets, such as smartphones and drones. Additionally, this framework includes an environmental sensor and an intelligent computing unit. The environmental sensor collects dynamic information about the number and location of devices to be charged, while the intelligent computing unit processes the sensor data to generate specific phase patterns to control the wireless power transmitter. Without the need for human intervention, this transmitter can achieve simultaneous wireless information and power transfer to multiple moving targets in random environments.■

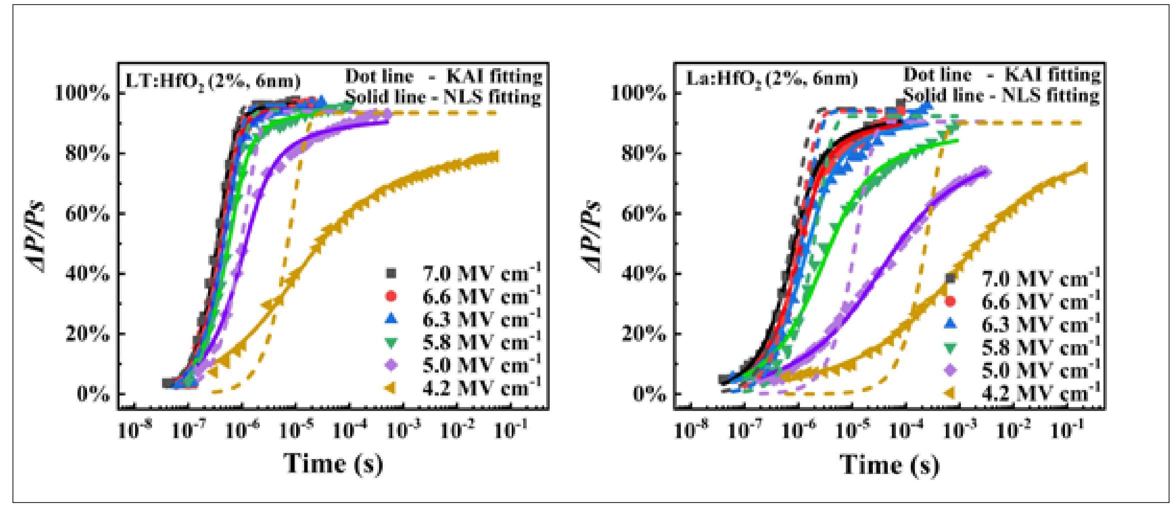


Paper Link: https://www.nature.com/articles/s41467-024-46984-4

Research & Academia
HIT TIMES 2024

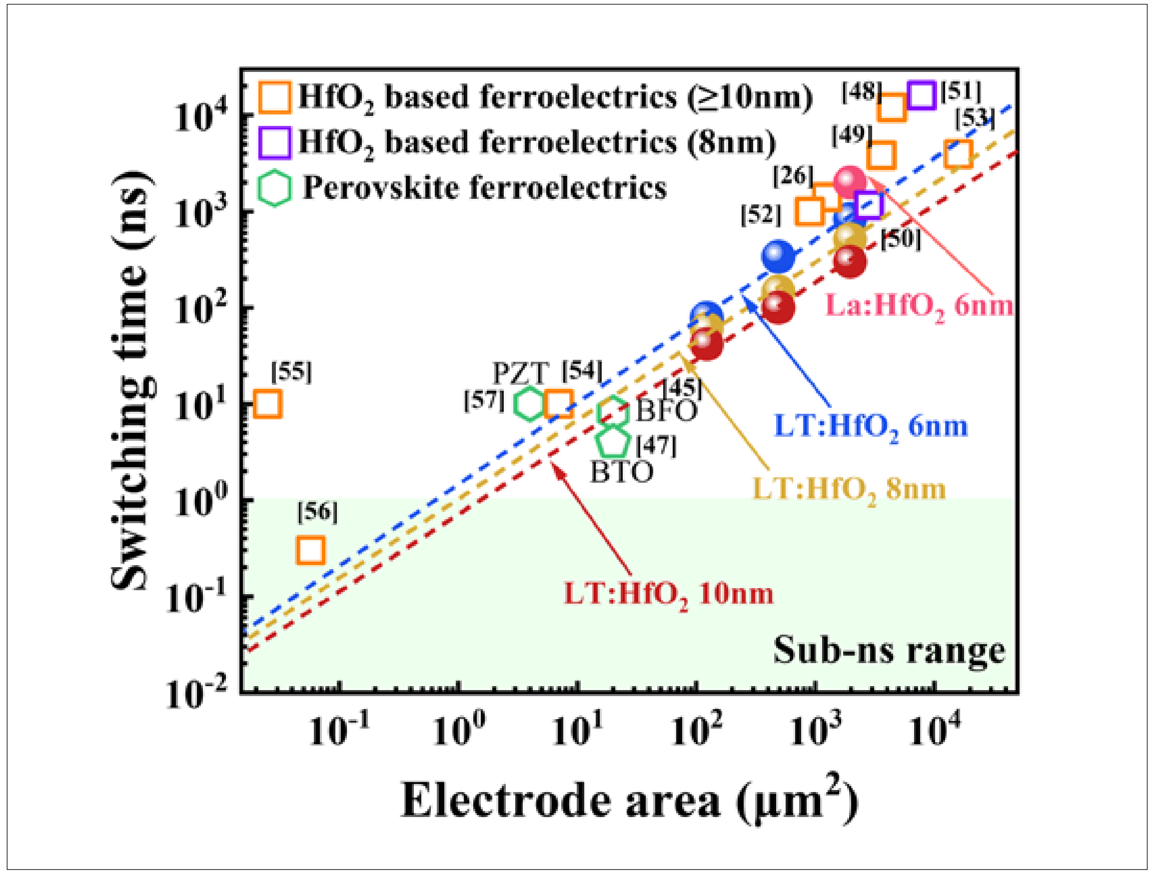
NEW PROGRESS IN HAFNIUM-BASED FERROELECTRIC FILMS, PROVIDING FOUNDATIONS FOR ULTRA-FAST FERROELECTRIC STORAGE

The research team led by Professor Zuhuang Chen from School of Materials Science and Engineering at Harbin Institute of Technology (Shenzhen Campus) has achieved substantial advancements in the field of hafnium-based ferroelectric thin films. The research result entitled **Enhanced Polarization Switching Characteristics of HfO_2 Ultrathin Films via Acceptor-Donor Co-Doping** were published in *Nature Communications*. The team innovatively applied the acceptor-donor co-doping modulation technique to the regulation of the polarization switching characteristics of hafnium-based ferroelectric devices, providing a new strategy to address the "double-edged sword" dilemma of oxygen vacancies in hafnium-based ferroelectric thin films. This work provides critical empirical and theoretical underpinnings for the progression of cutting-edge, high-performance ferroelectric memory devices.



The ferroelectric phase of HfO_2 is metastable, and oxygen vacancies, the most prevalent defect type in HfO_2, play a significant role in stabilizing this metastable ferroelectric phase. The discovery of ferroelectricity in HfO_2 thin films, which are utilized as gate materials in MOSFET, has presented new opportunities for resolving ferroelectric storage challenges of CMOS compatibility and high-density integration. However, oxygen vacancies also exert adverse effects on device performance. In particular, the pinning effect of oxygen vacancies on ferroelectric domain walls leads to a reduction in the switching speed of HfO_2-based ferroelectrics, placing HfO_2-based ferroelectric storage at a disadvantage in terms of read and write speeds. Addressing the “double-edged sword” effect of oxygen vacancies is crucial for enhancing the polarization switching characteristics of HfO_2 ferroelectrics, and it is key to achieving hafnium-based ferroelectric storage with both high polarization and rapid read and write capabilities

In response to the aforementioned issues, Professor Zuhuang Chen’s team pioneeringly applied a donor (Ta)-acceptor (La) co-doping method to modulate the properties of HfO_2-based ferroelectrics. This method effectively stabilizes the polar phase of HfO_2-based films while reducing the oxygen vacancy content within films simultaneously, contributing to the enhanced film quality. By means of this technique, HfO_2-based ferroelectric devices exhibiting both high polarization and rapid switching characteristics have been achieved, with the switching time as low as



sub-nanoseconds, comparable to perovskite-based ferroelectrics. Moreover, the high-quality of films and broadened energy plateau for metastable phase ensure the ferroelectricity at ultra-thin thicknesses, with the group demonstrating the stable ferroelectricity in co-doped HfO_2 films as thin as 3 nm. The detrimental role of oxygen vacancies for the polarization switching is elucidated, and the mechanism by which the co-doping method reduces the switching energy barrier is also clarified. The proposed co-doping strategy is of significant importance in defect modulation of HfO_2-based ferroelectrics, achieving reduced switching energy barriers, enhanced ferroelectric properties, and increased switching speeds. This provides effective guidance for accelerating the practical application of HfO_2-based ferroelectric thin films in the low-power, fast, and non-volatile memory devices.■

Paper Link: https://www.nature.com/articles/s41467-024-47194-8

IMPORTANT PROGRESS IN THE CONTROLLABLE PREPARATION OF LARGE-SIZE SINGLE-CRYSTAL METAL FOILS WITH HIGH-INDEX FACETS

The research team led by Professor Hu PingAn from School of Materials Science and Engineering at Harbin Institute of Technology has made important progress in the preparation of large-size single-crystal metal foils with high-index facets. The relevant results were published in the journal of *Advanced Materials* under the title **Prestrain Guided Yield of Large Single-Crystal Nickel Foils with High-Index Facets**.

The preparation of single-crystal metal foils with high-index facets has important scientific significance and great application potential in fundamental research. The abundant arrangement characteristics of atoms on high-index facets, including stepped and kinked facets, enable them with a highly unsaturated coordination environment. This feature confers strong epitaxial action for the growth of high-quality van der Waals film materials and electrochemical

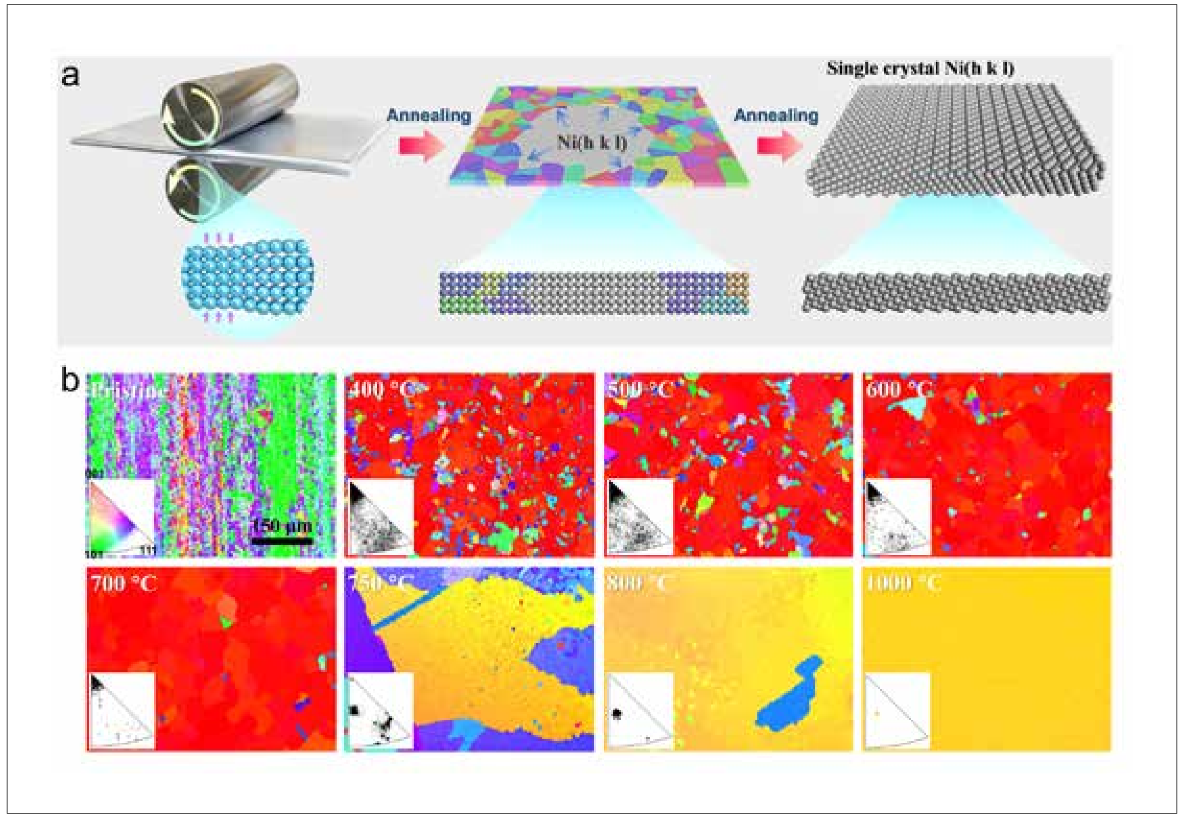


Figure 1. Prestrain guided production of large single-crystal nickel foils with high-index facets. a) Schematic illustration of abnormal grain growth induced by preapplied cold stress through roller pressing. b) Inverse pole figure (IPF) color maps of the evolution of crystallographic orientation of prestressed nickel foils with increasing annealing temperature, in which the insets are the responding IPF contours.

reduction capacity. For example, the step edges of the high-index surface facilitate the continuous epitaxial growth of single-crystal graphite film on single-crystal high-index nickel foils. Additionally, single-crystal films and unidirectional nanoribbons of transition metal dichalcogenides can be grown on low-symmetry vicinal facets with varying Miller indices. However, the controllable synthesis of large single-crystal metal foils with high-index facets remains a great challenge because high-index facets with high surface energy are not preferentially formed thermodynamically and kinetically.

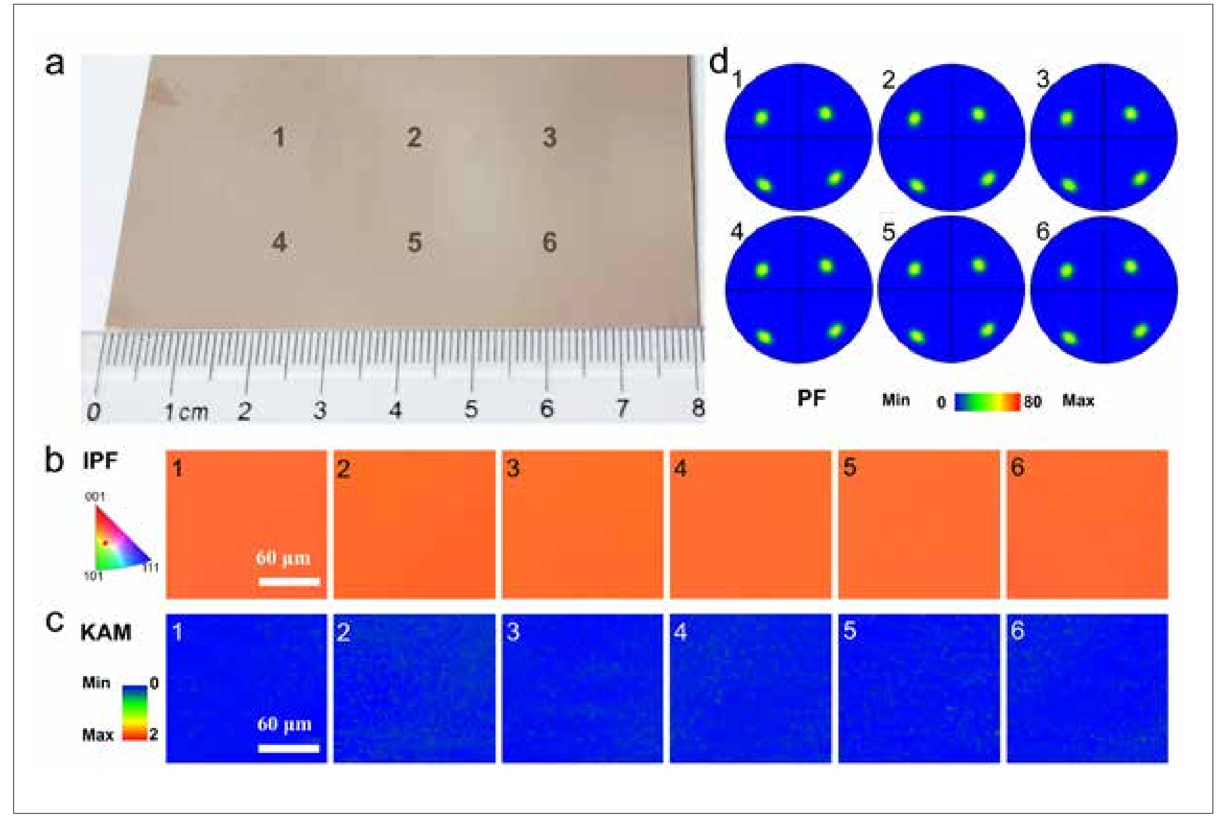


Figure 2. The characterizations of single-crystal Ni(014) foil larger than 5×8 cm^2. a) Optical image of single-crystal Ni(014) foil. b–d) EBSD IPF maps in the normal direction b), KAM maps c), and (001) pole figures d) of the as-obtained Ni(014) foil collected at the corresponding positions marked in (a).

To address this problem, the research team led by Professor Hu PingAn proposed a cold forming prestrain engineering technology for the controllable production of single-crystal nickel foils with high-index facets, with the largest one exceeds 5×8 cm^2 in size. The strain energy serves as the driving force to facilitate abnormal grain growth. By adjusting the prestrain, large single-crystal nickel foils with diverse high-index facets can be obtained. The thermodynamic analysis of the internal mechanism underlying the formation of high-index facets through prestrain regulation is conducted. Molecular dynamics simulation

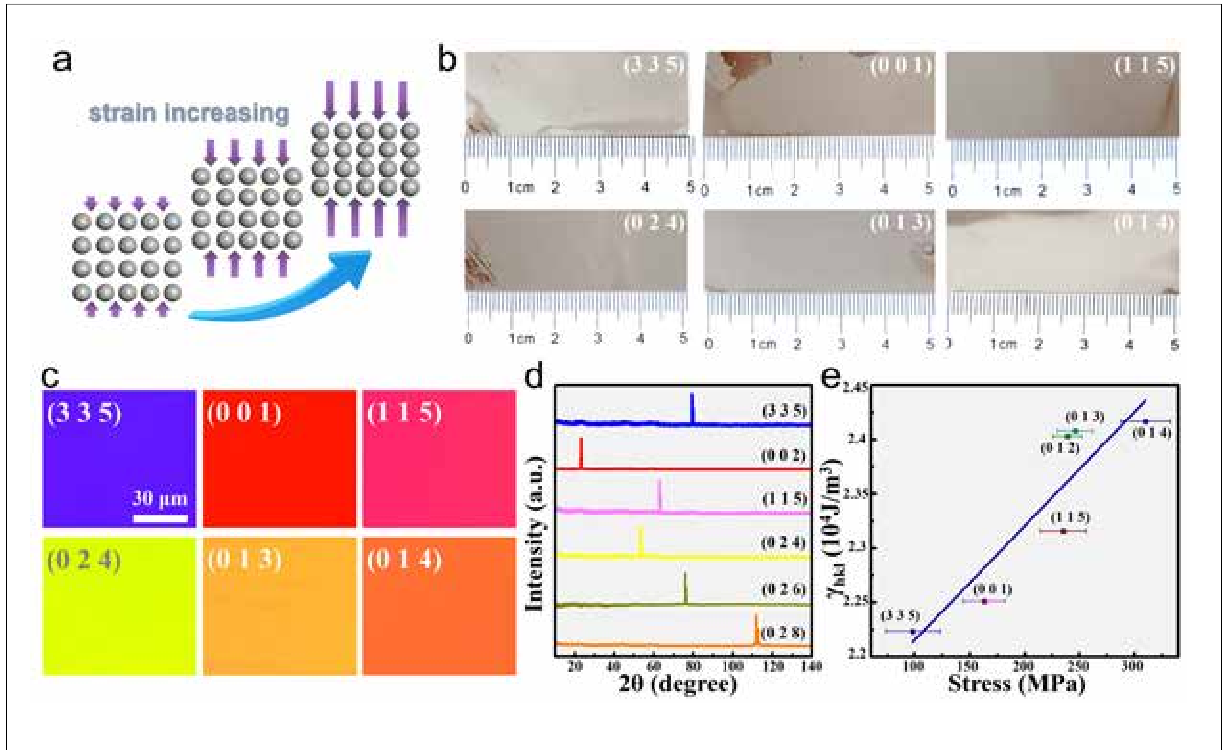


Figure 3. Single-crystal nickel foils with various facet indices adjusted by prestrain. a) Schematic diagram of the atomic model with increasing strain. b) Optical images of the six representative types of single-crystal nickel foils. c) EBSD IPF maps of the as-prepared single-crystal nickel foils, with normal crystal orientation of (335), (001), (115), (024), (013), and (014), respectively. d) XRD (molybdenum-based target) patterns of the six nickel foils in (b). e) Relationship between the stress and the surface energy obtained from various single-crystal facets.

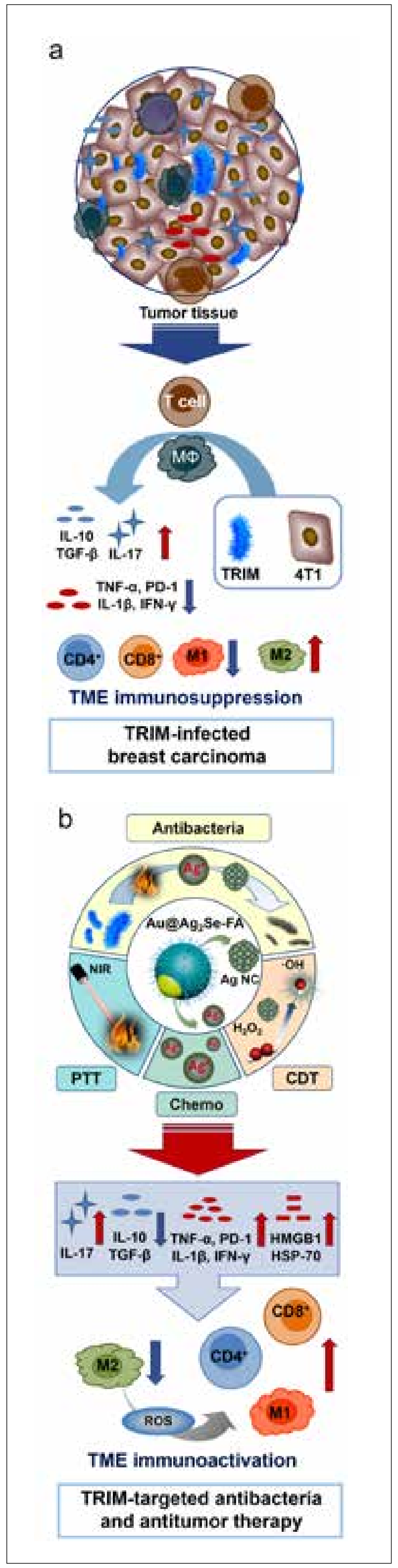
is employed to explain and replicate the phenomenon of multiple crystallographic orientations resulting from prestrain regulation. Furthermore, high-quality graphite films were prepared on the single-crystal Ni(012) foils, and the graphite/single-crystal Ni(012) foil composites exhibit exceptional thermal conductivity. This study hence presents a novel approach for the preparation of single-crystal nickel foils with high-index facets, which is beneficial for the epitaxial growth of certain two-dimensional materials.■

Paper Link: https://doi.org/10.1002/adma.202400248

NEW PROMISE FOR THE COMPLETE CURE OF MALIGNANT TUMORS

The team led by Professor Miao Yu from the School of Chemical Engineering and Technology and Professor Ye Sun from the School of Instruments has made significant progress in modulating the tumor immune microenvironment and advancing antitumor therapy. Their research, titled **Long-Term Relapse-Free Survival Enabled by Integrating Targeted Antibacteria in Antitumor Treatment**, has been published in *Nature Communications*. In this work, they successfully activated antitumor immune responses and restored antitumor immune surveillance through targeted intratumoral antibacteria combined with multimodal antitumor treatment, achieving long-lasting immunity and effective inhibition of distant tumors. This realization marks the complete cure of malignant tumors.

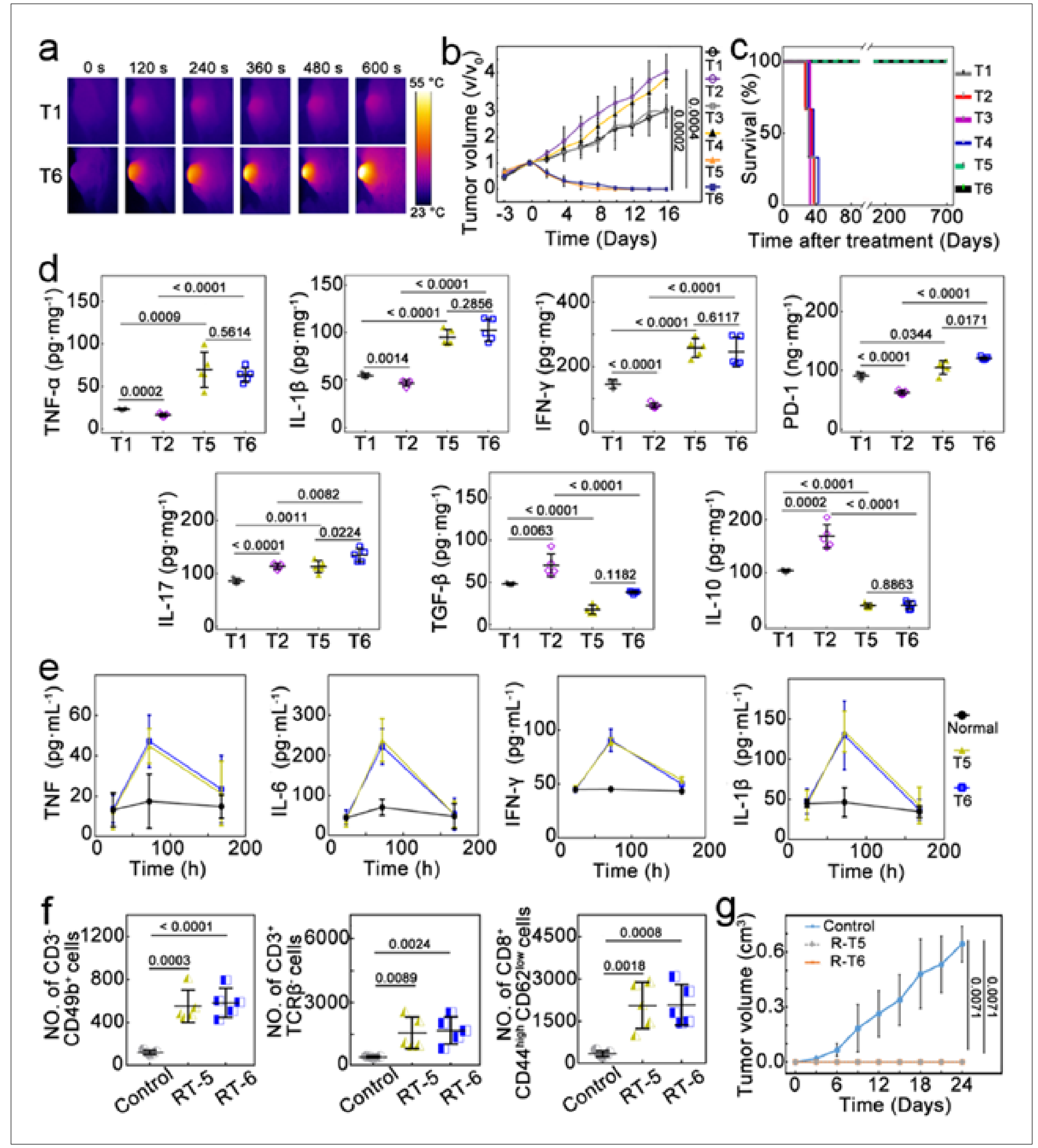
In recent years, the study of tumor-resident intracellular microbiota (TRIM) has emerged as a hotspot in understanding the initiation, progression, and recurrence of malignant tumors. TRIM can infiltrate tumors from surrounding tissues or the bloodstream, reducing the efficacy of chemotherapy drugs, exacerbating drug



toxicity, and promoting the growth and metastasis of tumor cells. However, the impact of antibacteria within the tumor microenvironment (TME) on tumor inhibition remains unclear.

Professor Yu and Sun's team constructed models of two highly prevalent malignant tumors, breast carcinoma (4T1) and prostate carcinoma (RM-1), both infected with *Escherichia coli* (*E. coli*). They confirm that TRIM upregulates the expression of immunosuppressive cytokines [IL-10, TGF-β] and pro-inflammatory cytokines IL-17, while downregulates the expression of other pro-inflammatory cytokines [IL-12, TNF-α, and IFN-γ] and PD-1. It also reduces the number of T cells and M1-type macrophages in the tumor area while increasing the number of M2-type macrophages. *In vivo* experiments demonstrate that the presence of bacteria not only exacerbates immunosuppression in the tumor regions directly infected by *E. coli* but also significantly intensifies immunosuppression in the tumor regions of mice raised in non-sterile environments, leading to a substantial increase in tumor growth rates (Fig.1a).

To address this challenge, the team designed and constructed a silver selenide shell-covered gold nanoagent and modified it with folic acid on its surface without the use of immune-stimulating drugs. This single agent can simultaneously achieve multimodal tumor suppression through photothermal therapy, chemodynamic therapy, and chemotherapy while enabling TRIM-targeted antibacteria (Fig.1b). By combining antibacterial and antitumor strategies, this approach effectively tackles the TRIM-induced issues of immunosuppression, excessive tumor growth, and recurrence. It successfully activates T cell immune responses and promotes the repolarization of M2-type to M1-type macrophages, triggering long-term antitumor immune memory. A relapse-free survival of >700 days is achieved (Fig.2). This work unravels the pivotal role of TRIM-targeted antibacteria in tumor inhibition and unlocks an unconventional route for immune regulation in the TME and a complete cure for cancer.

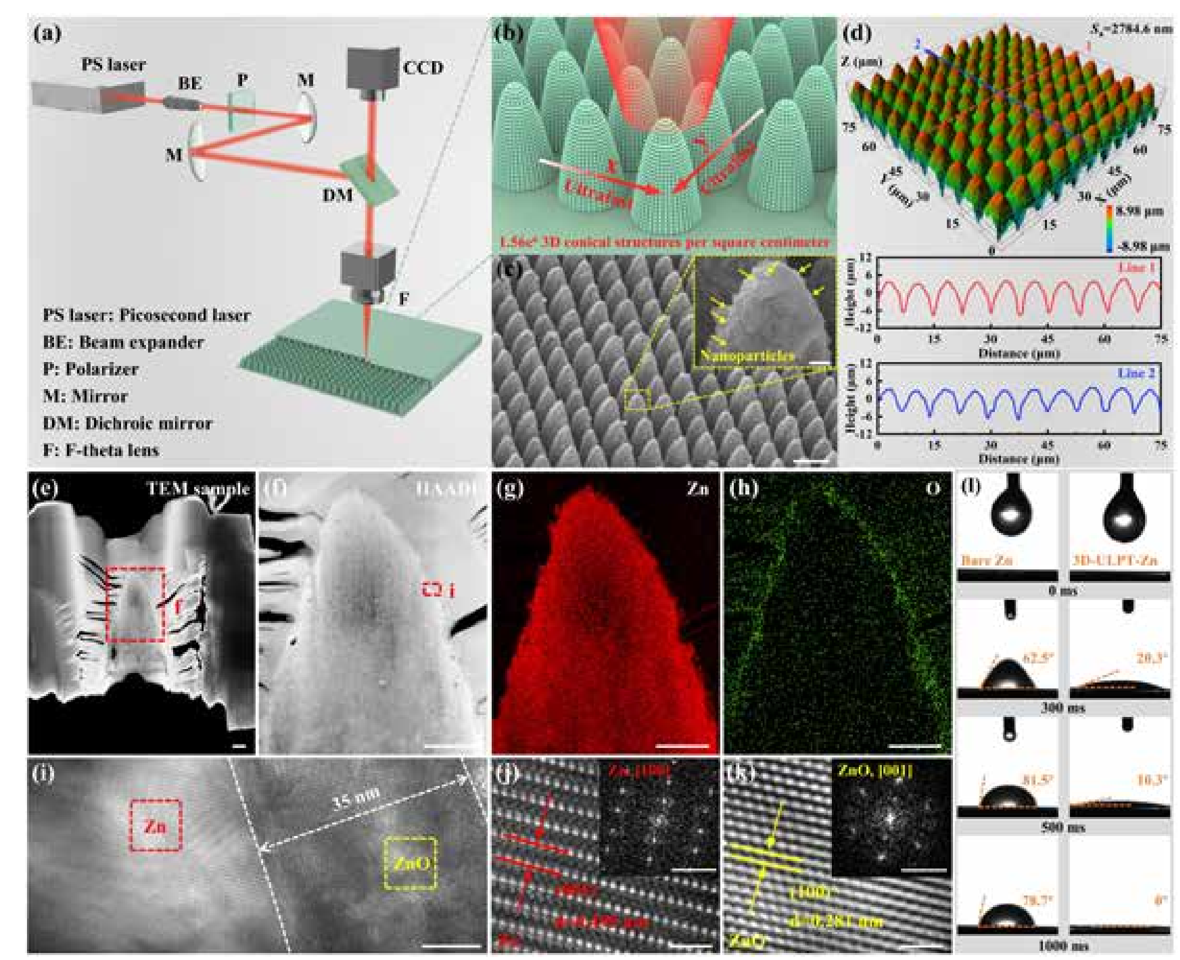


Paper Link: https://www.nature.com/articles/s41467-024-48662-x

NEW INSIGHTS FOR THE DEVELOPMENT OF HIGH-PERFORMANCE ZINC-BASED ENERGY STORAGE DEVICES

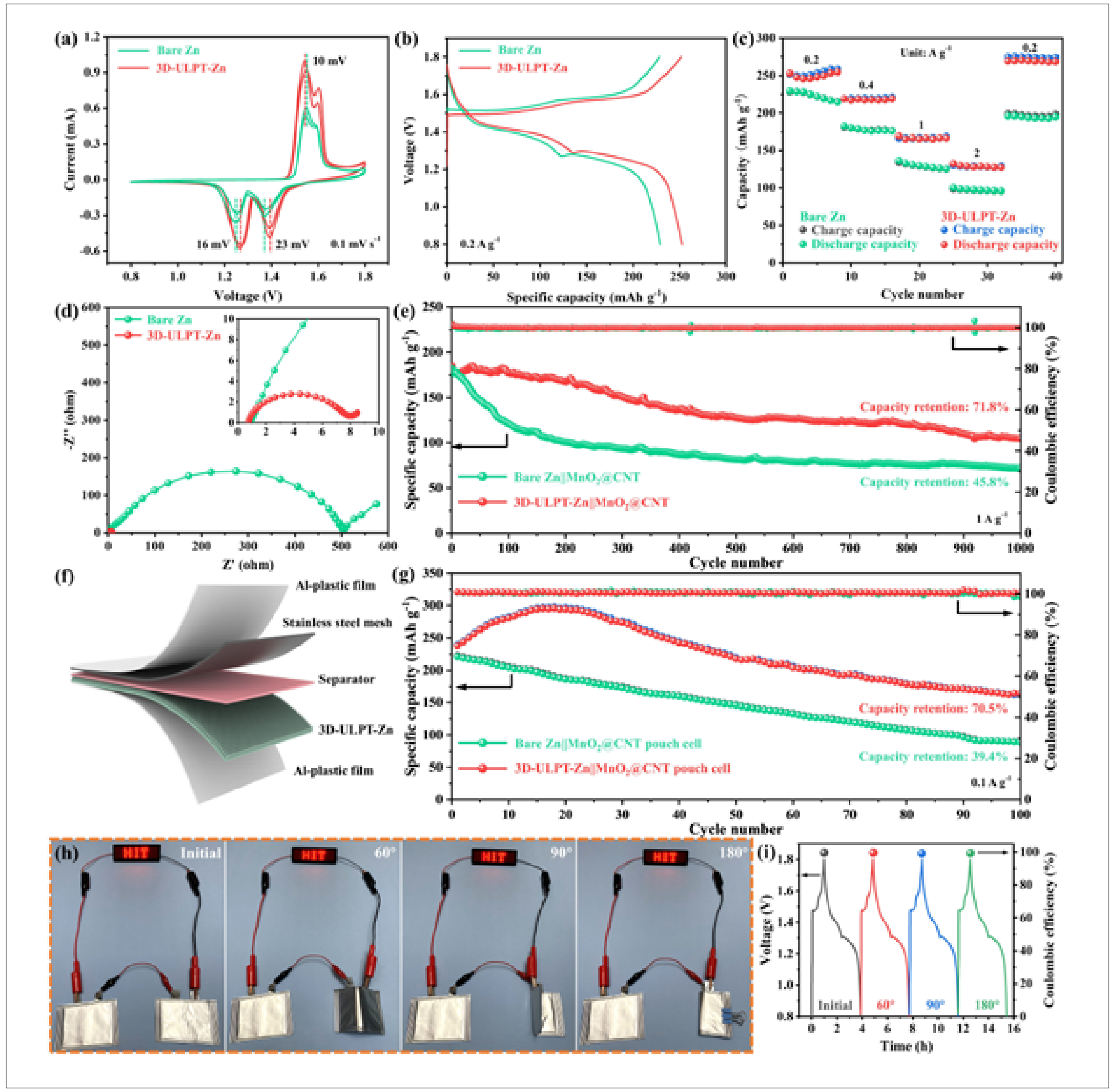
Professor Lijun Yang's team at the School of Mechanical and Electrical Engineering of Harbin Institute of Technology has precisely regulated the electrochemical performance of zinc anodes using ultrafast laser micro-nano manufacturing technology. Their research, titled **Ultrafast Laser One-Step Construction of 3D Micro-/Nanostructures Achieving High-Performance Zinc Metal Anodes**, has been published in *PhotoniX*, providing new insights into the practical application of ultrafast laser micro-nano manufacturing technology in the field of zinc-based energy storage.

Zinc metal is a promising anode material for aqueous zinc-ion batteries due to its abundant storage capacity, non-toxicity, environmental friendliness, low electrochemical potential, and high theoretical capacity.



However, during the cycling process of aqueous zinc-ion batteries, uncontrolled dendrite growth on the zinc anode surface and harmful corrosion/side reactions significantly shorten device performance.

To address these issues, the team employed an ultrafast laser one-step fabrication method to construct functional three-dimensional micro-/nano structures on the surface of zinc metal anodes, effectively resolving the problems of dendrite growth and corrosion/side reactions associated with zinc anodes. The three-dimensional micro-/nano structures integrate low local current density, rapid zinc ion transport, and ultra-high zinc deposition space, optimizing the electric field distribution, zinc ion concentration



distribution, and nucleation behavior of zinc on the electrode surface. This results in uniform zinc deposition and suppression of corrosion/side reactions, demonstrating excellent electrochemical performance and flexibility in practical applications. This innovative method offers a new approach for constructing three-dimensional micro-/nano structures on metal electrode surfaces to achieve high-performance energy storage devices.■

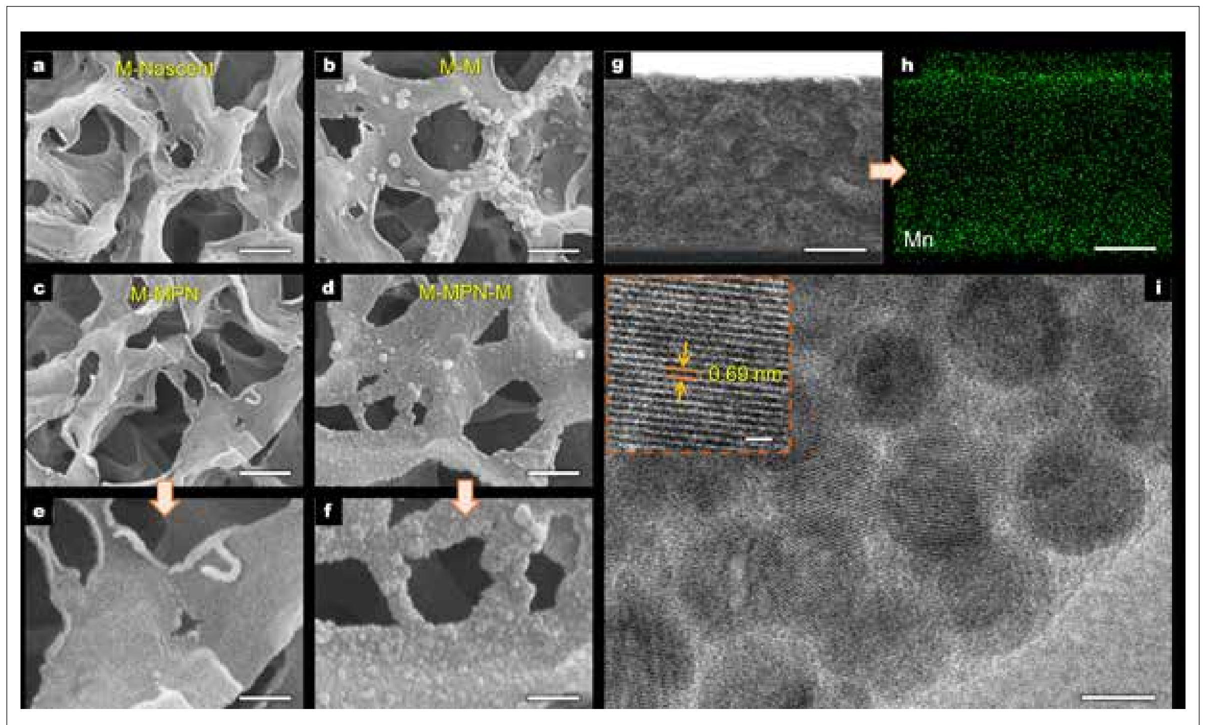
Paper Link: https://photonix.springeropen.com/articles/10.1186/s43074-024-00122-x

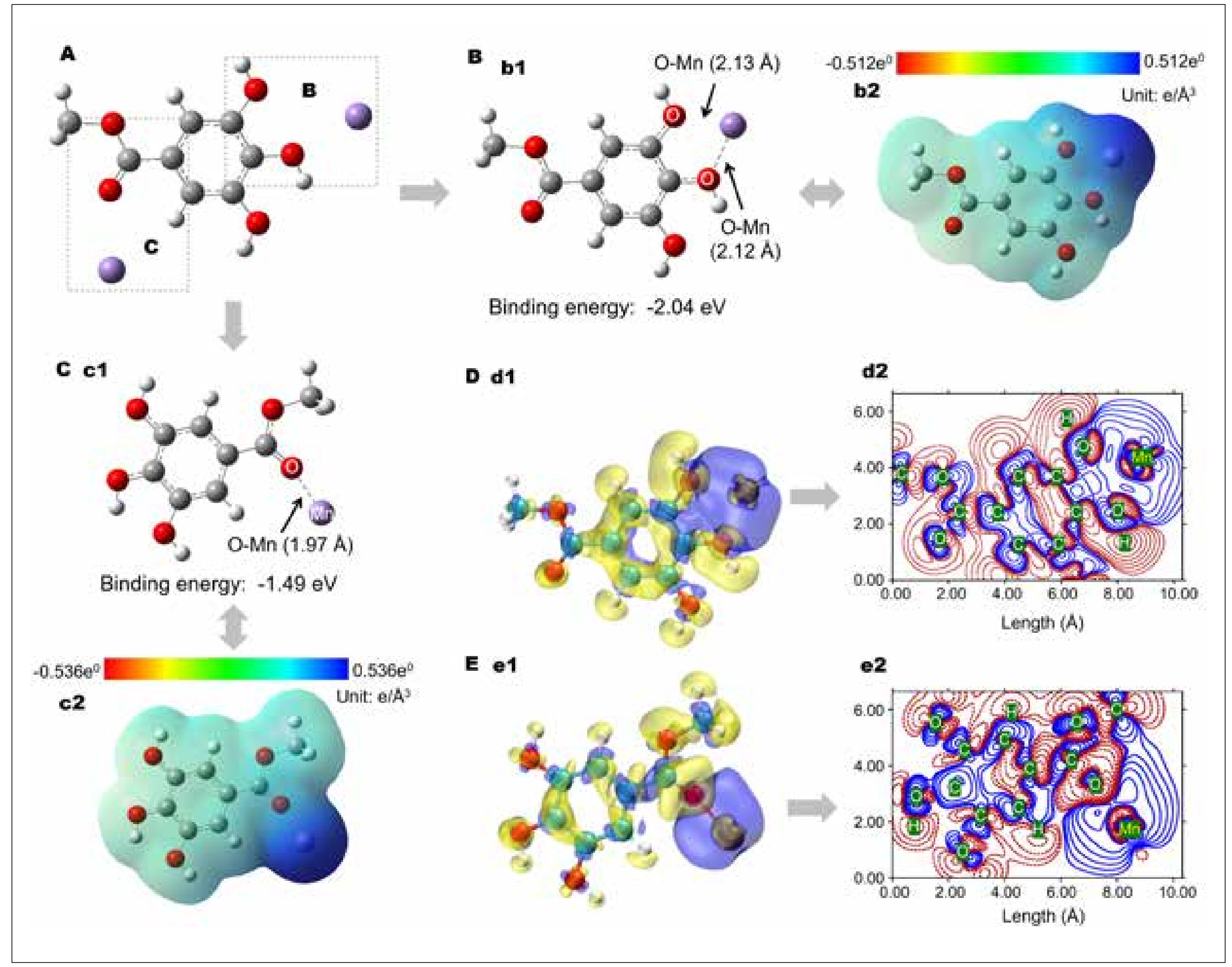
A BREAKTHROUGH IN SYNTHESIZING IN-SITU SELF-CLEANING MEMBRANES UNDER MILD CONDITIONS

Professor Lu Shao's team from the School of Chemical Engineering and Technology at Harbin Institute of Technology has proposed a chelation-directed interface mild mineralization strategy to synthesize catalytically active metal oxide mineralized in-situ self-cleaning membranes. Recently, their related paper titled **Chelation-Directed Interface Engineering of In-Place Self-Cleaning Membranes** was published in the *Proceedings of the National Academy of Sciences* **(PNAS)**, providing broad application prospects for practical water remediation, materials science, nanotechnology, catalysis, and biomedicine.

By 2050, water scarcity is expected to pose a severe threat to human survival and development. Membrane separation, as a low-carbon and environmentally friendly technology, has enormous potential for application in drinking water treatment, wastewater treatment, and resource recovery. However, traditional membrane processes are significantly hindered by widespread membrane fouling and require energy- and cost-intensive cleaning and maintenance. Conventional preparation methods often need to be conducted under conditions of heating, strong oxidants, or strong acid environments, and the deposited coatings tend to be thick, easily blocking membrane pores and reducing permeability. Hence, synthesizing and constructing catalytically self-cleaning ultrathin nanocoatings under mild conditions is extremely challenging.

To address this issue, Professor Lu Shao's team proposed a chelation-directed interface mild mineralization strategy, where the mineral precursor undergoes controllable mild hydrolysis mediated by chelation in the interlayer. By employing a metal-polyphenol ionic crosslinking network, they can gently mediate the mineralization growth of metal oxides, constructing self-cleaning separation membranes in a weakly alkaline aqueous solution at room temperature. The chelation-directed mineralization nanocoatings in this study are extremely thin (about 18





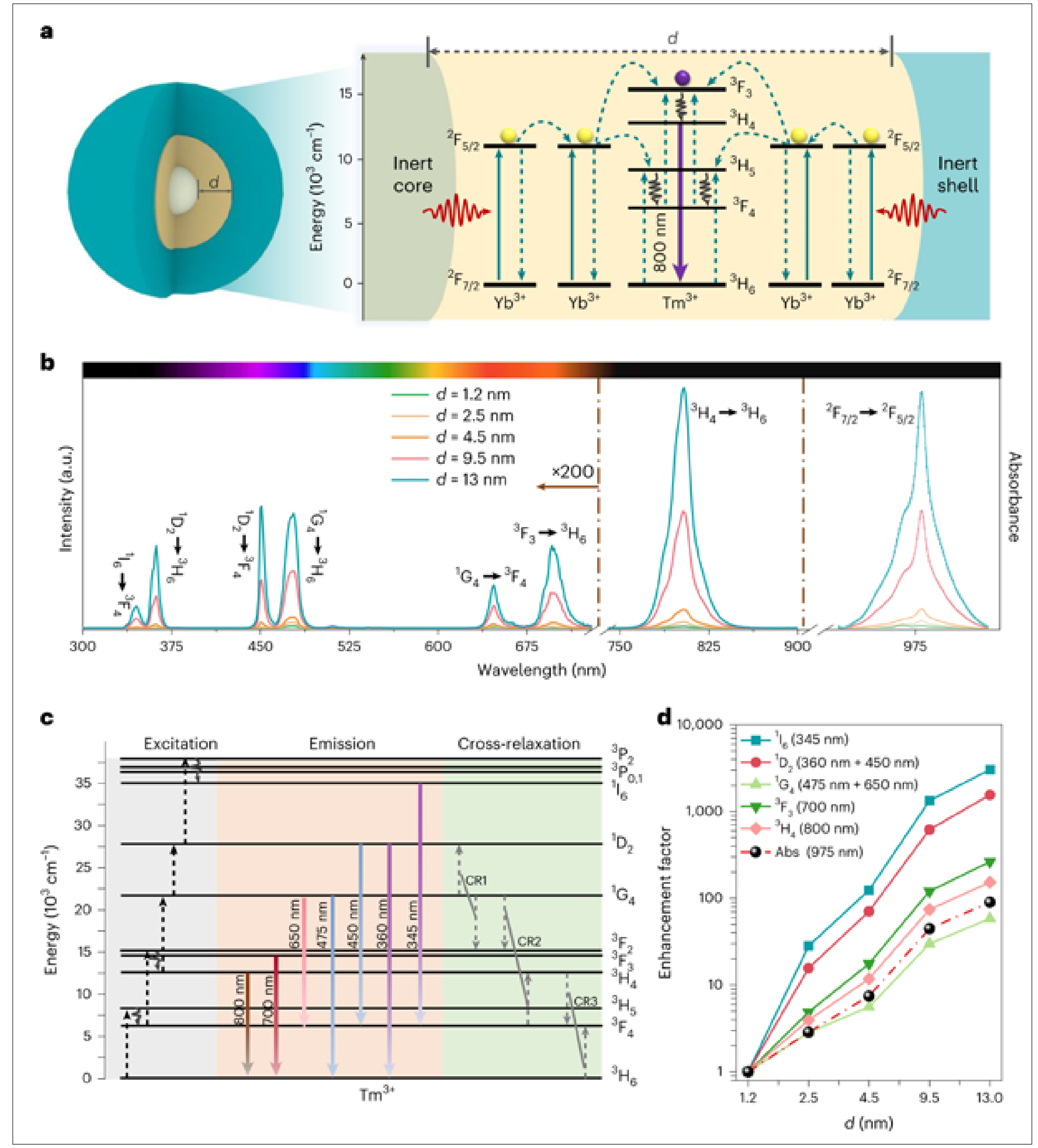
nanometers), exhibiting superhydrophilicity, high polarity, and ultra-low adhesion to crude oil, making the separation of water-in-oil emulsions feasible. During crossflow filtration, the flux recovery rate after in-situ regeneration exceeds 99.9%, alleviating the need for traditional non-in-situ cleaning. Compared to control membranes and simple hydraulic cleaning, the in-situ self-cleaning regeneration quality of the chelation-directed mineralization modified membranes is 48 times and 6.8 times greater, respectively. Additionally, the team analyzed the interaction mechanisms of the precursors through density functional theory calculations and multiple wave function analyses, revealing possible mechanisms of chelation-directed mineralization.■

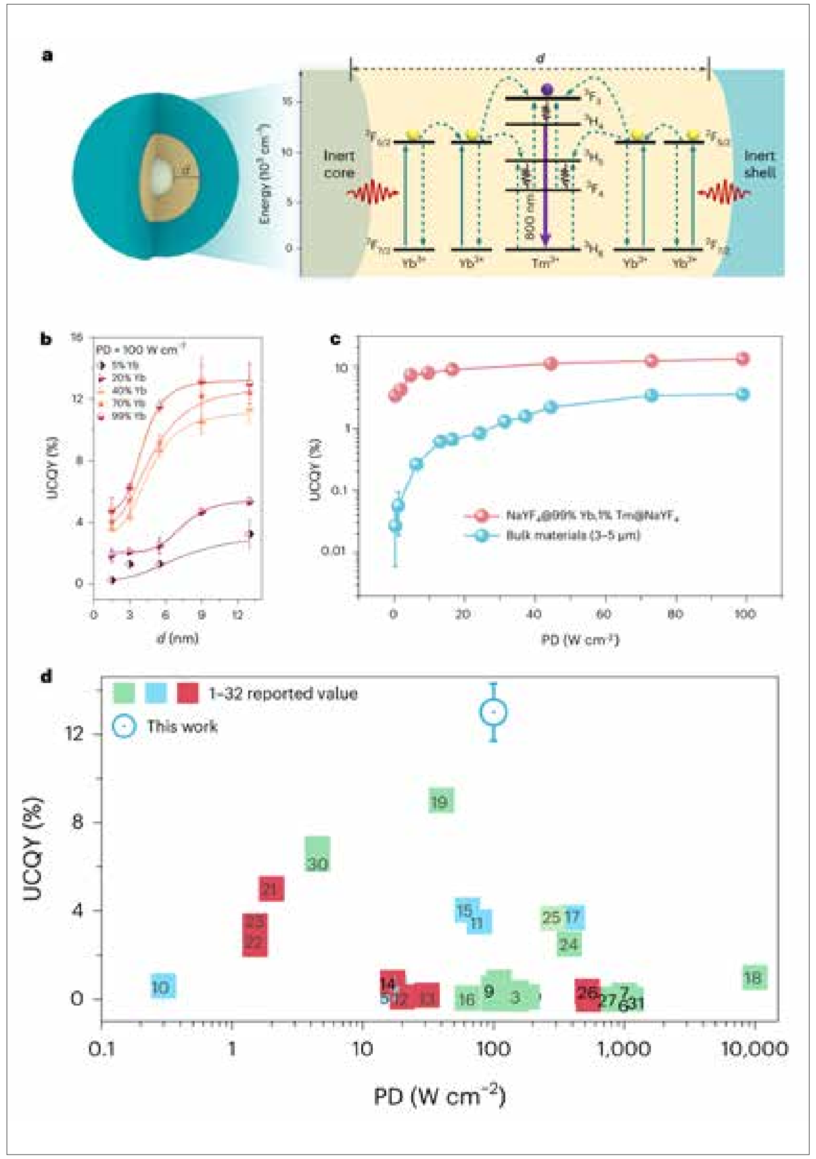
Paper Link: https://www.pnas.org/doi/10.1073/pnas.2319390121

NEW "SIZE EFFECT" AMPLIFIES THE LUMINESCENT QUANTUM YIELDS IN LANTHANIDE DOPED UPCONVERSION NANOSTRUCTURES

Researchers from the School of Chemical Engineering and Technology at Harbin Institute of Technology, led by Professor Guanying Chen, have made a breakthrough in the field of upconversion luminescence of lanthanide doped nanoparticles. Their research results, titled **Size-Dependent Lanthanide Energy Transfer Amplifies Upconversion Luminescence Quantum Yields**, were published in *Nature Photonics*, changing the traditional understanding of the size effect on upconversion luminescence and providing a new approach for the design of lanthanide-doped luminescent nanoparticles.

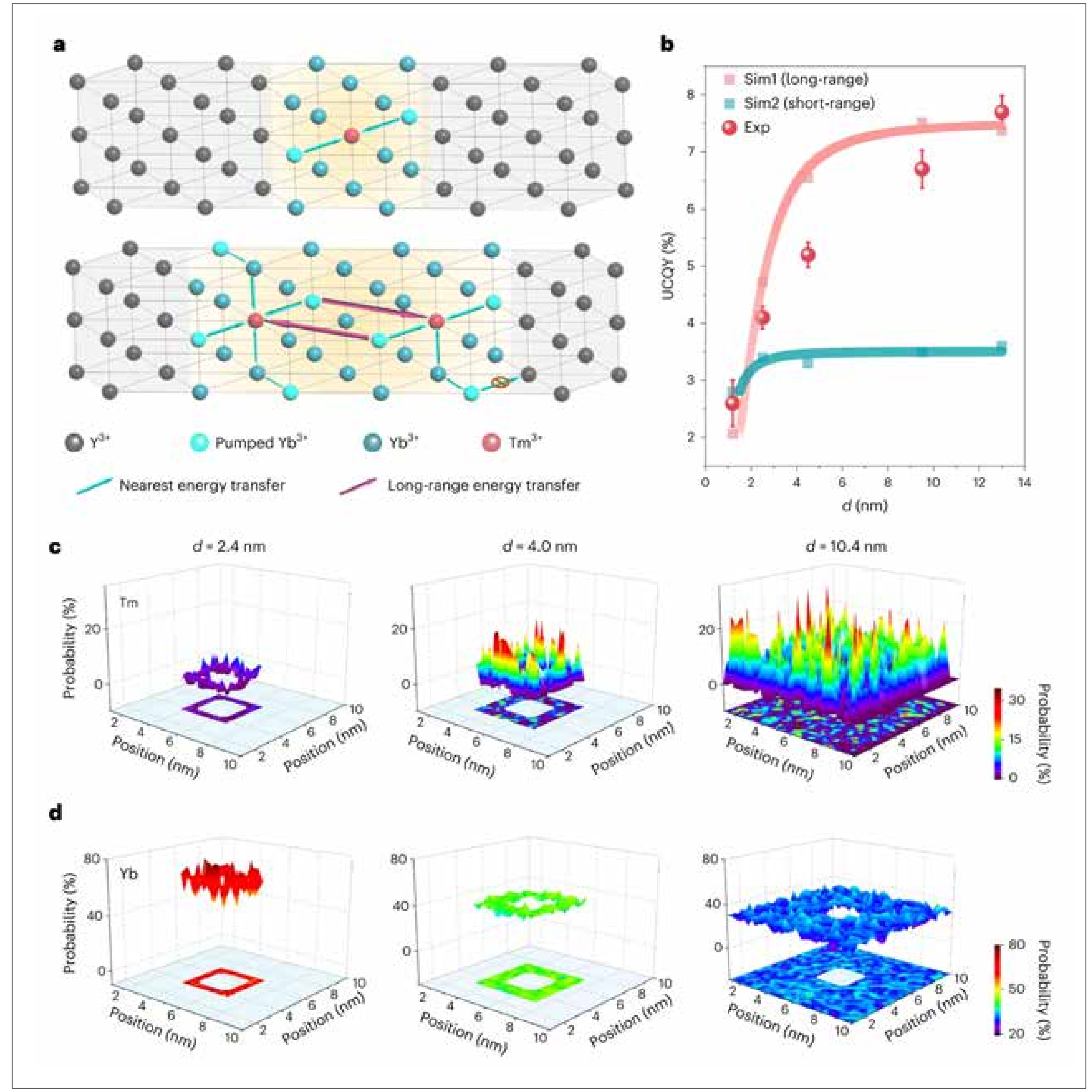
Lanthanide-doped upconversion nanoparticles are an emerging class of anti-Stokes luminescent materials with important applications in anti-counterfeiting, biomedicine, microlasers, super-resolution nanoscopy, volumetric displays, and solar cells. However, due to the severe luminescence quenching effects in nanostructures (including defect quenching and size-induced surface quenching), the energy transfer process in the excited state suffers from serious energy dissipation. As a result, the quantum yield of upconversion materials at the nanoscale is typically several orders of magnitude lower (about 10-1000 times) than their bulk counterparts, greatly limiting their related application research. Achieving high quantum yields of upconversion luminescence is of great significance for rare earth luminescence research.





Based on this, the research team led by Professor Guanying Chen constructed hexagonal phase ytterbium- thuliumco-doped fluoride upconversion nanocrystals with a sandwich-like core-shell-shell structure. By utilizing the effective confinement and isolation of the inert materials in the inner core and outer shell layers, and precisely controlling the thickness of the intermediate layer (1.2-13 nm), they demonstrated the size-dependent effect on the upconversion quantum efficiency of this nanoparticles. Spectroscopic studies and theoretical micro-models confirmed that this effect is not related to the traditional surface quenching effect, but is mainly induced by the long-range (10 nm scale) energy transfer process between the lanthanide ions. Ultimately, the team achieved an upconversion quantum yield as high as 13% in sub-50 nm fluoride nanocrystals (laser wavelength: 980 nm, power density: 100 W/cm^2), which is about 4 times higher than the micrometer-sized hexagonal phase ytterbium-thulium co-doped bulk counterpart under the same excitation conditions. This upconversion quantum yield is the highest record for upconversion nanoparticles to date.

This study first revealed the physical mechanism of size-dependent long-range energy transfer between rare earth ions in nanocrystals, not only changing the long-held concept of the physical picture of energy transfer between lanthanide ions (which should not have size dependence), but the related materials will also play an important role in relevant nanophotonics and biophotonics applications. At the same time, the research



results achieved a high upconversion quantum yield of up to 13% through control, surpassing the upconversion quantum yield of bulk materials, which breaks long-existing conceptual understanding since the discovery of the upconversion phenomenon in the 1960s that the upconversion luminescence efficiency of nanomaterials is lower than that of bulk materials.■

Paper Link: https://www.nature.com/articles/s41566-024-01393-3

NANOBODY-BASED CHEMO-OPTOGENETIC PLATFORM FOR SPATIOTEMPORAL CONTROL OF CELLULAR PROCESSES

Professor Xi Chen in The Life Science Center at Harbin Institute of Technology, has made a breakthrough in the field of chemo-optogenetics. The group has developed a nanobody-based chemo-optogenetic platform called PANCID (Photoactivatable Nanobody Conjugate Induced Dimerization), which can be used for spatiotemporal control of cellular processes. The research finding was published in the journal *Advanced Science* as a cover article, under the title *Photoactivatable Nanobody Conjugate Dimerizer Temporally Resolves Tiam1-Rac1 Signaling Axis*.

Using PANCID as a light control tool, the study found that the T-cell lymphoma invasion and metastasis inducing factor 1 (Tiam1) and Rac1 are both "molecular oscillators" in the signaling pathway. Their rapid or slow activation can regulate different downstream pathways, providing an important basis for further exploring the molecular mechanisms of the two tumor-related factors.

Chemically induced dimerization (CID) is a means of controlling cellular processes based on the principle of proximity-induced activation. To achieve higher spatiotemporal precision, light-responsive versions of CID systems, known as pCID, have also been developed. However, the existing pCID tools have limitations, such as long incubation times, inability to directly control endogenous proteins, and the need to wash away excess pCID molecules to exert their effects. Therefore, the development of a more efficient, user-friendly, and high-affinity pCID system is of great importance.

To address these issues, the Xi Chen team developed PANCID. The PANCID dimerizer molecule consists of three main components: a photoactivatable trimethoprim ligand, a

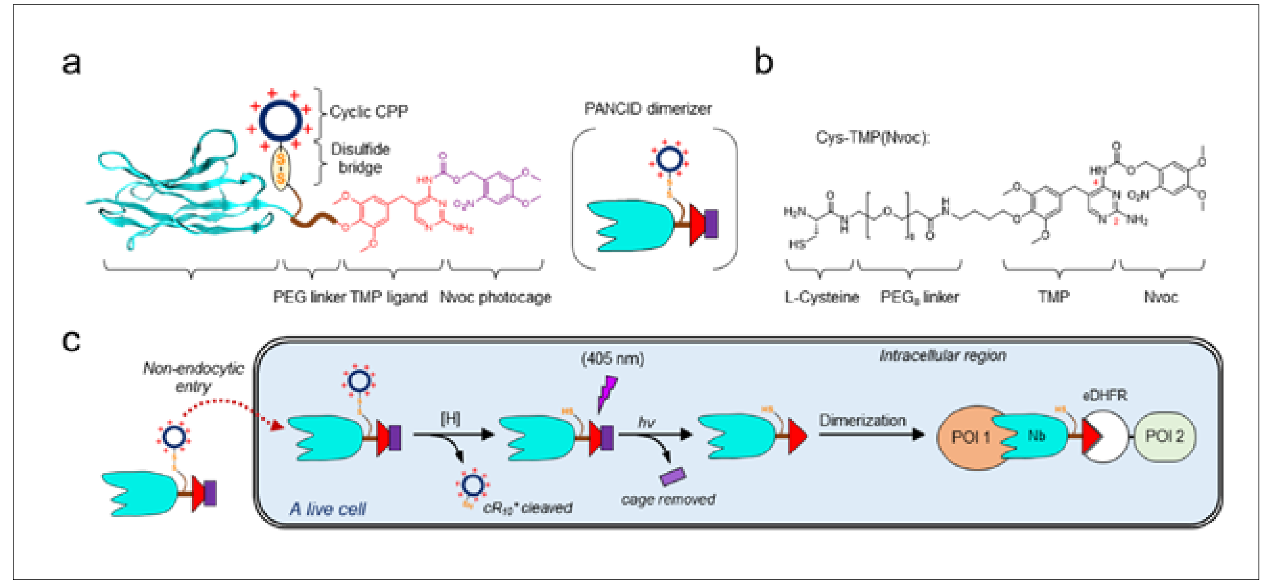


Figure 1. Design and working principle of a PANCID photodimerizer. a) Structural elements of a PANCID. b) The chemical structure of Cys-TMP(Nvoc) used for preparation of a PANCID. c) Schematic view of the general working principle of PANCID inside a live cell.

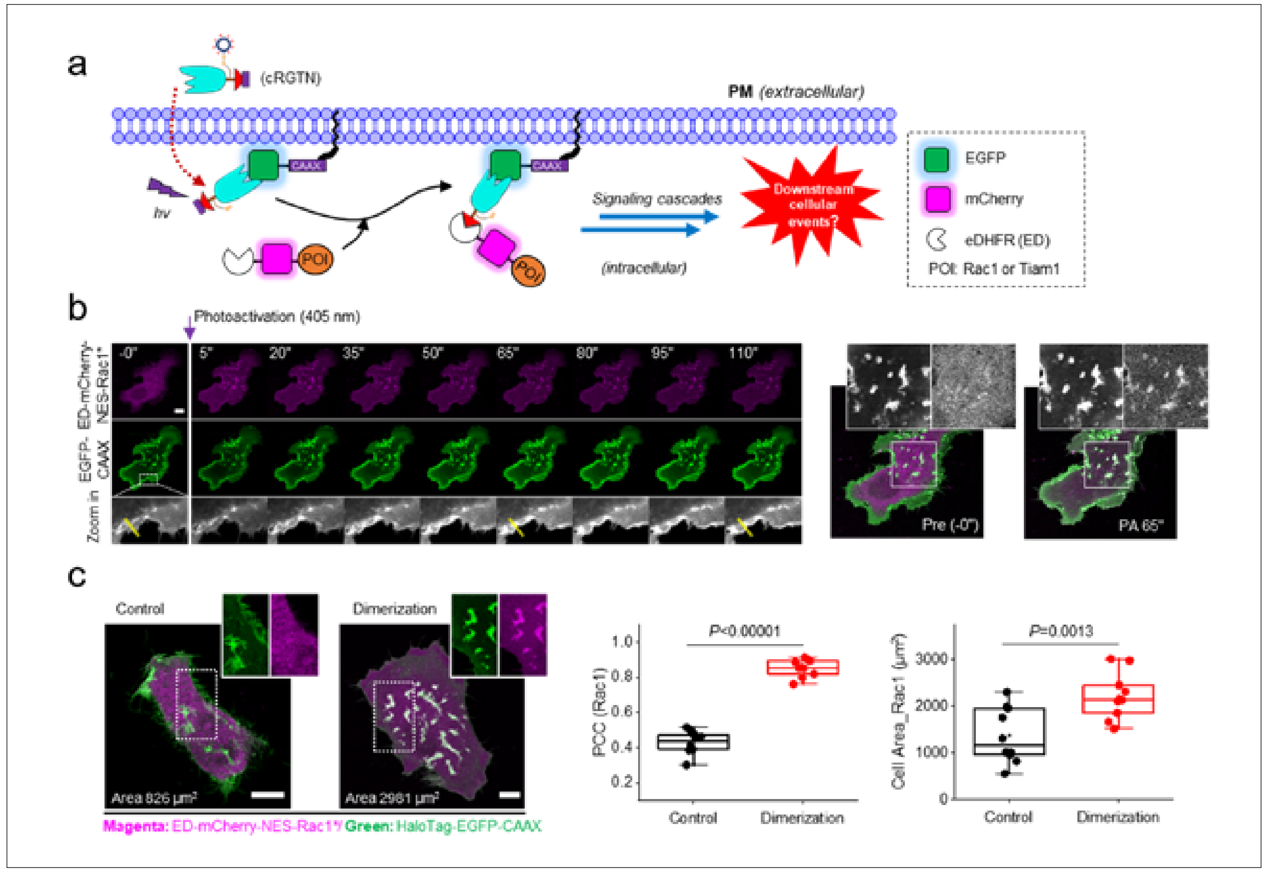


Figure 2. The PANCID photodimerizer cRGTN temporally dissects the function of Rac1. a) Schematic view of the experimental design. b) Time-lapse confocal micrographs of eDHFR-mCherry-NES-Rac1* treated with cRGTN. c) Confocal micrographs of live HeLa cells co-expressing ED-mCherry-NES-Rac1* and treated with TMP-Cl dimerizer. d) Statistical quantification of PCC co-localization degree and the cell area increase treated with TMP-Cl dimerizer.

nanobody module, and a cyclic decaarginine (cR10*) cell-penetrating peptide. Benefiting from the high affinity, high specificity, and potential to regulate endogenous proteins of the nanobody module, PANCID has superior characteristics compared to the classic pCID tools. The cR10* cyclic cell-penetrating peptide facilitates rapid intracellular delivery, allowing PANCID to easily penetrate the cell membrane like a small molecule. Furthermore, the nanobody module can be easily replaced, demonstrating the modular nature of PANCID and its potential for broader applications.

The research team used PANCID to study the Tiam1-Rac1 signaling axis. Tiam1 is a direct upstream factor of Rac1, activating Rac1 and leading to the formation of lamellipodia. However, Tiam1 can also activate other factors besides Rac1, resulting in different

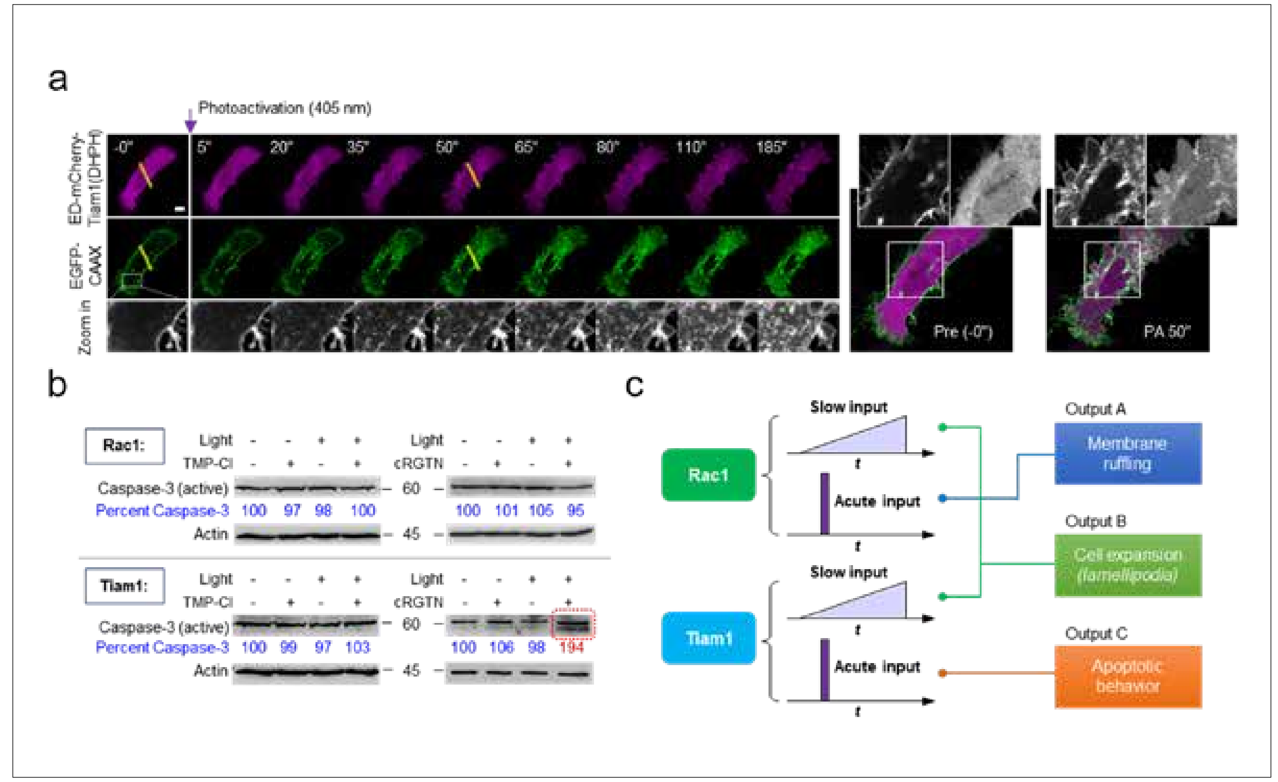


Figure 3. The PANCID dimerization system temporally resolves Tiam1 mediated signaling cascade. a) Time-lapse micrographs of a representative HeLa cell co-expressing eDHFR-mCherry-Tiam1(DHPH) and EGFP-CAAX treated with cRGTN. b) WB analysis of either Rac1* or Tiam1(DHPH) activated by cRGTN or TMP-Cl, with or without light illumination confirmed that only acute activation of Tiam1(DHPH) by light can cell apoptosis being induced. c) Schematic summary of the key findings in this study shows that slow or acute activation of Rac1 or Tiam1 would lead to rather different cellular events.

cellular events such as cell survival and apoptosis. Therefore, it was unclear how the different biological functions of Tiam1 and Rac1 are switched. The research team used the PANCID system to transiently control Tiam1 and Rac1 proteins in the Tiam1-Rac1 signaling pathway, and found that rapid or slow activation of Tiam1 and Rac1 can produce different cellular responses. Slow activation of Tiam1 and Rac1 promotes an increase in cell area and the formation of lamellipodia. Rapid activation of Rac1 leads to the formation of membrane ruffles, while rapid activation of Tiam1 quickly induces cell apoptosis, accompanied by the activation of caspase-3.

Paper Link: https://onlinelibrary.wiley.com/doi/10.1002/advs.202307549

NEWS & EVENTS

UNIVERSITY STUDENTS EMBRACE WINTER FUN AT ANNUAL SNOWBALL FIGHT EVENT

Harbin, China — In a spirited display of camaraderie and winter joy, students at Harbin Institute of Technology gathered for the much-anticipated Annual Snowball Fight event in December. Held on the university's beautiful campus, the event attracted students from various faculties, all eager to participate in this delightful winter tradition.

As the snow blanketed the campus, the atmosphere buzzed with excitement and laughter. Students bundled up in warm clothing, brandishing their gloves and scarves, formed teams and strategized for the friendly snowball battle. The event kicked off at the sports field of the university, with a brief introduction from the event organizers, who emphasized the importance of teamwork and sportsmanship.

"We wanted to create an opportunity for students to unwind, have fun, and connect with each other during the winter season," said the organizer, a member of the Student Union. "Snowball fights are a great way to relieve stress and enjoy the outdoors together!"

The snowball fight commenced with a countdown, and within moments, the air was filled with cheerful shouts and laughter as students launched snowballs at each other. The event was not only about competition; it also encouraged creativity, with some students building forts for cover while others devised clever tactics to outmaneuver their opponents.

"I haven't had this much fun in ages!" exclaimed a junior student, giggling as they ducked behind a snow fort. "It's great to see everyone coming together and just enjoying the winter weather."

In addition to the snowball fight, the event featured a hot tea station, where students could warm up and recharge after their playful battles with tea and coffee. The aroma of hot coffee and the sight of steaming cups added to the festive atmosphere, creating a cozy gathering spot for participants to share stories and laughs.

As the snowball fight continued, students enjoyed friendly competition and formed new friendships. The event fostered a sense of community, bringing together students from different backgrounds and majors, all united by the joy of winter play.

"I love how events like this help us bond as a campus community," said another student. "It's important to take a break from our studies and enjoy moments like these."

The Annual Snowball Fight event concluded with a group photo, capturing the smiles and laughter of participants against the backdrop of a winter wonderland. Organizers expressed their gratitude to all who participated and contributed to the event's success.

With the positive response from students, the organizers plan to continue this beloved tradition in the coming years, hoping to make it an even bigger celebration of winter fun and community spirit.■

WINTER OLYMPIC CHAMPION INSPIRES STUDENTS WITH ICE SKATING MASTERCLASS

In an exciting event that brought the community together, Winter Olympic champion Hong Zhang hosted a special ice skating masterclass for students at Harbin Institute of Technology on December 20th, 2023. The event, designed to inspire and educate young athletes, attracted a large group of enthusiastic students eager to learn from one of the best in the sport.

In 1956, Harbin Institute of Technology introduced an ice skating elective course, which has been a distinctive feature of the university ever since. According to statistics, in recent years, the number of students taking ice skating classes each year has reached around 4,000 to 5,000, and the size of the ice rink has expanded by more than two times. This winter, approximately 4,400 students across the university participated in ice skating classes.

As the students laced up their skates, Hong Zhang, who won a gold medal in skating at the recent Winter Olympics, shared insights into their journey, emphasizing the importance of dedication, practice, and passion for the sport. “Skating is not just about technique; it’s about expressing yourself and enjoying every moment on the ice,” she said, motivating the students to embrace their own skating journeys.

The masterclass began with a warm-up session, where the champion demonstrated fundamental skating techniques, including balance, posture, and basic maneuvers. Students watched intently, taking notes and asking questions as Hong Zhang shared tips that have contributed to her success.

“I’ve always wanted to learn how to skate properly, and having an Olympic champion teach us is a dream come true!” exclaimed a junior student. “It’s incredible to see how passionate she is about the sport, and I can’t wait to apply what I’ve learned today.”

Following the demonstration, students had the chance to practice under the champion’s guidance. Hong Zhang offered personalized feedback, helping each student improve their skills and build confidence on the ice. Laughter and cheers filled the rink as students attempted new techniques and celebrated each other’s progress.

The event also included a Q&A session, where students eagerly asked about Hong Zhang's training regimen, experiences at the Olympics, and advice for aspiring athletes. "It's important to set goals and work hard, but don't forget to have fun along the way," she advised, encouraging students to enjoy the process of learning.

The masterclass concluded with a group photo, capturing the joyous atmosphere of the day. As students left the rink, they expressed their gratitude for the opportunity to learn from an elite athlete and their excitement to continue improving their skating skills.

"I feel inspired to keep practicing and maybe even compete one day!" said a student, beaming with enthusiasm.

The event was organized by the PE department

of the university, aiming to promote physical activity and inspire the next generation of athletes.

With the success of this masterclass, organizers hope to host more events featuring sports champions in the future, fostering a community of encouragement and excellence in athletics.■

UNIVERSITY STUDENTS SHOWCASE CREATIVITY AT ANNUAL ICE SCULPTURE ACTIVITY

On December 22nd, 2024, students from Harbin Institute of Technology gathered on campus for the much-anticipated Ice Sculpture Activity, an event that has become a cherished winter tradition at the university. The event brought together students from various cities, allowing them to express their creativity while enjoying the beauty of winter.

As the temperature dipped below freezing, students armed with chisels, saws, and their artistic visions

began transforming large blocks of ice into stunning sculptures. With themes ranging from mythical creatures to abstract designs, the students showcased their talents and teamwork in crafting intricate works of art.

“I’ve never done anything like this before, and it’s amazing to see what we can create with just ice,” said a sophomore art major student. “It’s a great way to bond with friends and bring our ideas to life.”

The event was organized by the university’s School of Architecture and Design, with support from the Student Union. Faculty members were on

hand to offer guidance and encouragement, emphasizing the importance of collaboration and innovation in the creative process.

In addition to the ice sculpting competition, the event featured live music, hot cocoa stations, and a “Students’ Choice” award where attendees could vote for their favorite sculpture. The lively atmosphere was enhanced by students and faculty alike coming together to cheer on the participants, contributing to a sense of community on campus.

“We wanted to create an engaging experience that not only fosters creativity but also strengthens the bonds between students,” said

the event coordinator. "Seeing the students work together and support one another is truly inspiring."

As the sun set, the sculptures began to shimmer under the soft glow of string lights, creating a magical winter wonderland. The top three sculptures, chosen based on creativity and craftsmanship, received prizes, including art supplies and gift cards to local businesses.

The Annual Ice Sculpture Activity not only provided a platform for artistic expression but also highlighted the importance of teamwork and community spirit among students. As the event concluded, participants expressed their enthusiasm for next year's activity, eager to return with new ideas and designs.

This year's ice sculpture event was a resounding success, leaving behind memories of laughter, creativity, and the warmth of camaraderie in the cold winter air.■

EMBRACING THE BEAUTY OF AUTUMN: A GLIMPSE INTO CAMPUS LIFE AT HIT

As the leaves begin to change color and the air turns crisp, autumn casts a magical spell over Harbin Institute of Technology. This season not only transforms the campus into a picturesque landscape of gold, orange, and red but also brings a vibrant energy to student life. From academic pursuits to social events, autumn at Harbin Institute of Technology is filled with unique experiences that foster community and growth.

A Scenic Campus Transformation

Walking through the campus during fall is like stepping into a painting. The trees lining the walkways are adorned with colorful foliage, creating a stunning backdrop for students as they move between classes. Many students take advantage of this natural beauty, enjoying leisurely strolls or study sessions on the lawns, enveloped in the warmth of the autumn sun.

News & Events
HIT TIMES 2024

Engaging Academic Activities

As the semester progresses, students at Harbin Institute of Technology dive into their studies with renewed focus. The fall semester is an exciting time, filled with lectures, group projects, and research opportunities. Professors often incorporate seasonal themes into their curriculum, sparking discussions that connect academic concepts to real-world experiences. Students are inspired to engage in critical thinking and collaboration, enhancing their learning journey.

Campus Activities

Additionally, cultural events and club activities flourish during this season. Student organizations host themed gatherings, workshops, and volunteer opportunities that encourage participation and inclusivity. Whether it's an art show, a food festival, or a charity run, there's always something happening on campus in the fall. Those activities foster a sense of community, allowing students to bond over shared experiences and create lasting memories.

Painting

Carving

Calligraphy

Jogging

Culinary Delights

As the temperatures drop, so do cravings for cozy comfort food. The dining halls and local cafes at Harbin Institute of Technology embrace the season by offering delicious autumn-inspired dishes. From hearty soups to handmade noodles, students indulge in seasonal flavors that warm both body and soul. Many students also take this opportunity to gather with friends for potluck dinners, sharing homemade dishes that reflect their diverse backgrounds.

Outdoor Sports

For those who enjoy the great outdoors, autumn presents the perfect opportunity for exploration. The nearby parks, sports field and nature trails become popular destinations for students seeking a break from their studies. Hiking, biking, and simply enjoying the beautiful scenery are favorite pastimes during this season. Student groups often organize outdoor excursions, fostering camaraderie and a love for nature.

A Time for Reflection and Gratitude

As the semester approaches its midpoint, autumn serves as a reminder for students to reflect on their goals and achievements. It's a time for gratitude, where students appreciate the friendships they've formed and the knowledge they've gained. Many take part in mindfulness activities, such as journaling or meditation, to center themselves and maintain balance amidst the busyness of academic life.

Conclusion

Autumn at Harbin Institute of Technology is a season filled with beauty, engagement, and reflection. From the vibrant campus scenery to the rich tapestry of activities and traditions, students embrace the spirit of the season while forging connections that will last a lifetime. As the leaves fall and the air becomes cooler, the warmth of community and the excitement of learning continue to thrive, making autumn a truly special time in university life.

HIT CONSTRUCTS WARM CORRIDORS TO ENSURE COMFORTABLE TRAVEL FOR STUDENTS IN COLD WINTERS

The winter season in Northeast China is particularly lengthy, lasting from November 1 to March 25 of the following year, totaling 145 days, with temperatures dropping as low as -30°C. As November arrives, influenced by heavy snowfall, temperatures in Harbin can plummet to -17°C. During extreme cold weather, the Northeast region issues snowstorm warnings, advising people to stay indoors, and schools also announce class suspensions.

To address the challenges of traveling in the frigid winter, Harbin Institute of Technology (HIT) recently announced the completion of its campus warm corridor project, designed to provide students with a warm and comfortable learning environment. As winter approaches with rapidly dropping temperatures and frequent snowstorms, the conditions for traveling within the campus have become increasingly harsh. In response to this challenge, Harbin Institute of Technology actively promoted the construction of warm corridors to ensure that students can freely reach classrooms, libraries, dining halls, and other facilities even in cold weather.

Design and Features of the Warm Corridors

Fully Connected: The construction of the warm corridors is divided into several phases, and has now achieved full connectivity, allowing students to quickly move between different buildings. The total length of the warm corridors is 1,330.13 meters.

Warm and Comfortable: The interior of the warm corridors is equipped with heating facilities, ensuring that students can travel in light clothing even in sub-zero temperatures.

Convenient Access: The warm corridor project ensures easy and efficient access throughout the campus, allowing students to navigate between the first and second campuses with ease. In just a five-minute walk, students can reach major buildings, including classrooms,

libraries, dining halls, dormitories, and gyms.

Feedbacks from Students

Many students have welcomed the construction of the warm corridors, believing that this initiative greatly enhances the convenience of daily commutes, making it easier for students to attend classes and engage in campus activities, all while staying sheltered from the harsh winter weather. Many student commented, "It's fantastic to be able to walk through the warm corridors in this weather! I can wear light clothing to class and feel very comfortable."

The construction of the warm corridors at Harbin Institute of Technology (HIT) is not only an enhancement of campus infrastructure but also a manifestation of the university's humanistic care for students. The school hopes that through this project, it can further improve the learning and living environment for students, allowing each student to feel warm and care during the cold winter months.

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