Program Booklet

International Conference on Photochemistry and Photofunctional Materials 2025

(ICPPM 2025)

November 28 (Fri) – December 1 (Mon), 2025
University of Shanghai for Science and Technology (USST)
Function Hall, Student Development Center

Welcome Message

Dear Colleagues and Participants,

It is with great pleasure and honor that I welcome you to the International Conference on Photocatalysis and Photofunctional Materials (ICPPM2025), held on November 29-30, 2025, at the University of Shanghai for Science and Technology. This conference brings together the brightest minds and leading researchers in the field of photocatalysis and its related topics from around the world.

As the discoverer of photocatalysis, I am thrilled to see the remarkable advancements and innovative research that continue to emerge in this field. The ICPPM 2025 serves as a platform for the exchange of ideas, collaboration, and the dissemination of cutting-edge research.

I extend my heartfelt gratitude to all the participants, speakers, and organizers for their dedication and hard work in making this conference a success. I am confident that the discussions and interactions over these two days will inspire new ideas, foster collaborations, and pave the way for future breakthroughs in photocatalysis.

Thank you for your participation, and I look forward to the fruitful and engaging sessions ahead.

Warm regards,

Akira Fujishima

Conference Chair, ICPPM 2025

General Information

Date, Location

- Conference Title: International Conference on Photochemistry and Photofunctional Materials 2025
- Date: November 28 (Fri) – December 1 (Mon), 2025
- Venue: University of Shanghai for Science and Technology (USST)

  No. 580 Jungong Rd, Yangpu District, Shanghai, China.

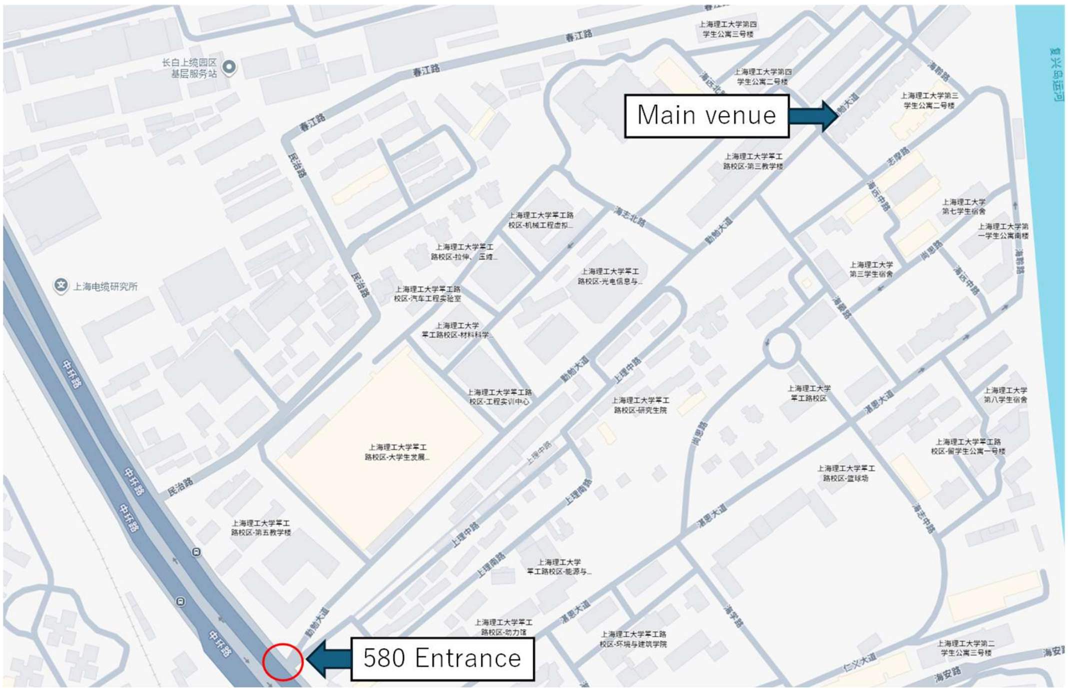
  Main Venue: Function Hall, Student Development Center

  Satellite Venue: Room 113, 117, No.3 Teaching Building
- Banquet: China Grain Hotel（小南国花园酒店）

  No. 777 Jiamusi Road, Yangpu District, Shanghai, China.

Conference Venue Information

USST Campus Map



Social Events

Welcome party

Place: China Grain Hotel（小南国花园酒店）

Date Time: November 28 (Fri) 17:00-18:00

Fee: Included in the meeting fee.

Banquet

Place: China Grain Hotel（小南国花园酒店）

Date Time: November 29 (Sat)18:30-20:30

(Bus transfer November 29 (Sat) 17:20)

Fee: Included in the meeting fee.

Optional tour

Date: December 1 (Mon)

Fee: Not included in the conference registration fee. Participants are kindly requested to cover their own expenses.

Program Schedule

Saturday, November 29, 2025

	8:00-9:00	Registration & Preparing for the Poster session
Main Venue (Student Development Center)	9:00-9:15	Opening group photo session
	9:15-9:30	President's Address
	9:30-9:55	Keynote Speech
	9:55-10:35	Academician Speech
	10:35-10:45	Coffee Break
	10:45-12:15	Invited Lecture
Outdoors	12:15-12:30	Group photo session
	12:30-13:20	Lunch Break
	13:20-14:20	Poster Session
1st Venue (No.3 Teaching Building 113)	14:30-15:45	Invited Lecture
	15:45-16:00	Coffee Break
	16:00-17:00	Invited Lecture
2nd Venue (No.3 Teaching Building117)	14:30-15:45	Invited Lecture
	15:45-16:00	Coffee Break
	16:00-17:00	Invited Lecture
	17:00-18:00	Bus Transfer
	18:30-20:30	Banquet China Grain Hotel

Sunday, November 30, 2025

1st Venue (No.3 Teaching Building 113)	9:00-10:15	Invited Lecture
	10:15-10:30	Coffee Break
	10:30-11:30	Invited Lecture
2nd Venue (No.3 Teaching Building 117)	9:00-10:00	Invited Lecture
	10:10-10:30	Coffee Break
	10:30-11:30	Invited Lecture
	11:30-13:00	Lunch Break/Venue Change
Main Venue (Student Development Center)	13:00-13:20	Academician Speech
	13:20-14:35	Invited Lecture
	14:35-14:50	Coffee Break
	14:50-16:10	Invited Lecture
	15:50-16:10	Academician Speech
	16:10-16:20	Closing Remarks

Saturday, November 29, 2025 - Sunday, November 30, 2025

Saturday, November 29, 2025

Entrance & Main Venue

8:00-9:00	**Registration & Preparing for the Poster session**

Main Venue

9:00-9:15		**Opening Group Photo**	
9:15-9:30		**President's Address** Xinyuan Zhu (USST)	Chair:Akira Fujishima
9:30-9:55		**Keynote Speech** Akira Fujishima (USST) Photocatalysis, Present Situation and Future Direction	Chair:Yasuaki Einaga
9:55-10:35		**Academician Speech**	
	9:55-10:15	Zhongfan Liu (Peking University) Super Graphene-Skinned Materials: Concept, Synthesis and Applications	Chair:Yasuaki Einaga
	10:15-10:35	Zhiyong Tang (Chinese Academy of Sciences) Membrane-based alternative to energy-intensive distillation processes	Chair:Yasuaki Einaga
10:35-10:45		**Coffee Break**	
10:45-12:15		**Invited Lecture**	Chair:Tsuyoshi Ochiai/Dayang Wang
	10:45-11:00	Zhongze Gu (Southeast University) Organ-on-a-chip and Bioanalysis	
	11:00-11:15	Yasuaki Einaga (Keio University) Electrochemical CO_2 reduction by boron-doped diamond electrodes	
	11:15-11:30	Xintong Zhang (Northeast Normal University) Surface Design of Advanced Photocatalysts for Energy and Environmental Applications	
	11:30-11:45	Hiroshi Irie (University of Yamanashi) Red Light-Inducible Solid-State Z-Scheme Photocatalysts for Overall Water Splitting and Carbon Dioxide Reduction with Water Oxidation	
	11:45-12:00	Yuzhu Ma (Inner Mongolia University) Boron-doped diamond powder for functional electrode material	
	12:00-12:15	Shengyao Wang (Shanghai Jiao Tong Univeristy) Design of Homogeneous-Heterogeneous Synergistic Photocatalytic System	
12:15-12:30		**Out door Group Photo**	
12:30-13:20		**Lunch Break**	
13:20-14:20		**Poster Session**	Chair: Manabu Kiguchi/Nobuhiro Hanada

1st Venue

14:30-15:45	**Invited Lecture**	Chair: Sachiko Matsushita/Yanhong Luo
	14:30-14:45	Sachiko Matsushita (Instutute of Science Tokyo) A new thermal energy conversion technology：Semiconductor-sensitized thermal cell
	14:45-15:00	Teng Li (University of Toyama) Anisotropy-Driven Charge Spatial Vectorial Separation and Migration
	15:00-15:15	Dayang Wang (Jilin University) Photocatalytic H_2O_2 Generation in Hydrogel-Sustained Benzyl-Integrated Frameworks for Solar Disinfection
	15:15-15:30	Tsuyoshi Ochiai (Kanagawa Institute of industrial Science and TEChnology (KISTEC)) Practical Evaluation Methods of Photocatalyst from Dialogue with the Industry
	15:30-15:45	Chiaki Terashima (Tokyo University of Science) In-liquid Plasma-engineered Titanium Dioxide Photocatalyst with Enhanced Performance in Environmental Purification
15:45-16:00	**Coffee Break**	
16:00-17:00	**Invited Lecture**	Chair: Kengo Hamada/Shengyao Wang
	16:00-16:15	Jinchen Fan (USST) Advancing Solar-to-Fuel Conversion through Innovative Photocatalytic and Photoelectrocatalytic Material Design
	16:15-16:30	Kengo Hamada (Kanagawa Institute of industrial Science and TEChnology (KISTEC)) Alternative Evaluation Methods for Photocatalytic Air Purification Performance: Modified Resazurin Ink and Fluorescence Probe Tests
	16:30-16:45	Zhi Jiang (Shanghai Jiao Tong University) Engineering $BiVO_4$-Based Photocatalysts for Overall Water Splitting
	16:45-17:00	Manabu Kiguchi(USST) Water Treatment using Photocatalysts in a Dispersion System Readily Separable from Water
17:00-18:00	**Bus Transfer**	
18:30-20:30	**Baquet China Grain Hotel**	

2nd Venue

14:30-15:45	**Invited Lecture**	Chair: Genki Ogata/Yuzhu Ma
	14:30-14:45	Yafei Sun (USST) Designing carbon supported metal nanoelectrocatalysts using the *d* charge descriptor
	14:45-15:00	Yu-Wu Zhong (Fuzhou University) Brightening the microcrystals of photofunctional metal complexes by light-harvesting energy transfer
	15:00-15:15	Kazutaka Akiyoshi (Nagoya University) Colloidal Synthesis of Less-Toxic Bismuth-Based Multinary Quantum Dots for Photovoltaics
	15:15-15:30	Yaobang Wang (Chinese Academy of Sciences) Organic photoelectrochemical energy storage materials
	15:30-15:45	Nobuhiro Hanada (USST) Nano-sized magnetic TiO_2-SiO_2/Fe3O_4 Photocatalysts and their application to photokilling of Lactobacillus casei and photocatalytic degradation of persistent herbicides
15:45-16:00	**Coffee Break**	
16:00-17:00	**Invited Lecture**	Chair: Kazutaka Akiyoshi/Zichao Lian
	16:00-16:10	Jinglun Du (Northeast Normal University) Strategies for Inert Molecule Conversion: From Electrochemical CO_2 Reduction to In-liquid Plasma Based Nitrogen Fixation
	16:10-16:20	Zongjing Lu (USST) Lithium-mediated electrochemical ammonia synthesis via the catalytic solid–electrolyte interphase
	16:20-16:30	Dan Zhang (USST) Facile Immobilization of Powdered Photocatalyst for Fabricating Self-Suspended Photocatalytic Millimeter Sized Spheres (MSSs)
	16:30-16:40	Zhipeng Ke (USST) Exploration the of eXtended ONIOM (XO) Method for Highly Accurate DFT Calculation of NMR Shifts
	16:40-16:50	Rajaram Sutar (Henan University) Waste Plastic-derived 3D Porous Photothermal Interfacial Evaporator for Synergistic Enrichment of Photothermal Efficiency and Lithium-Ion Kinetics
	16:50-17:00	Zhanchong Zhao (USST) Visible-Light-Driven Degradation of Bisphenol A in Recirculating Water Using Monolithic $BiVO_4$ Photocatalytic Foam Ceramics
17:00-18:00	**Bus Transfer**	
18:30-20:30	**Baquet China Grain Hotel**	

Sunday, November 30, 2025

1st Venue

9:00-10:15	**Invited Lecture** Chair: Sachio Yoshihara/Liu Cihui	
	9:00-9:15	Yoshiaki Nomura (USST) Electrochemical Photolysis of Triazine Herbicides in Agricultural Water Using a $Fe_3O_4/SiO_2/TiO_2$ Photocatalyst
	9:15-9:30	Yanhong Luo (Chinese Academy of Sceinces) Highly efficient sunlight-driven CO_2 hydrogenation to methanol over Ni-based intermetallic catalysts under atmospheric pressure
	9:30-9:45	Cihui Liu (Nanjing Normal University) Janus adhesive hydrogel scaffold for monitoring pressure and shape changes in human intestinal sphincter
	9:45-10:00	Baoshun Liu (Wuhan University of Technology) Slow Photoindud Electron Relaxations of Semconductors: Equipments and Softwares
	10:00-10:15	Sachio Yoshihara (Utsunomiya University) Photoacoustic Spectroscopy for Electrochemical Interface Analysis: Advances and Applications
10:15-10:30	**Coffee Break**	
10:30-11:30	**Invited Lecture** Chair: Linlin Duan/Changhua Wang	
	10:30-10:45	Changhua Wang (Northeast Normal University) Solution Plasma Driven Production of Hydrogen Peroxide
	10:45-11:00	Linlin Duan (USST) Oriented Assembly of Mesoporous Catalytic Materials Based on Single-Micelle Building Blocks
	11:00-11:15	Haibo Ding (Southeast University) Vascularized brain organoids with 3D-printed artificial vessels
	11:15-11:30	Genki Ogata (Keio University) In vivo Drug Monitoring Using Boron-Doped Diamond Microelectrodes
11:30-13:00	**Lunch Break**	

2nd Venue

9:00-10:00	**Invited Lecture**	Chair: Yu-Wu Zhong/Jinchen Fan
	9:00-9:15	Wenwei Lei (Yanshan University) Bionic Gel-Derived Photothermal and Photocatalytic Materials
	9:15-9:30	Yinglin Wang (Northeast Normal University) Highly-Stable PbS Quantum Dot Inks For High-Efficiency Near-infrared Optoelectronic Devices
	9:30-9:45	Jin Luo (State University of New York at Binghamton) Nanomaterials and Their Applications in Catalysts and Sensors
	9:45-10:00	Haibo Yang (East China Normal University) Rotaxane Dendrimers
10:00-10:30	**Coffee Break**	
10:30-11:30	**Invited Lecture**	Chair: Yaobing Wang/Wenwei Lei
	10:30-10:45	Tao Yuan (USST School of Materials) Super Graphene-Skinned Materials: Concept, Synthesis and Applications
	10:45-11:00	Zhaoyue Liu (Beihang University) Light-controlled ion translocation in conducting polymer membrane
	11:00-11:15	Takeshi Kondo (Tokyo University of Science) Structural modulation of layered oxide cathode materials for high-performance sodium-ion batteries
	11:15-11:30	Bo Jiang (Shanghai Normal University) Manipulation of active site for photocatalytic CO2 reduction to value-added chemicals
11:30-13:00	**Lunch Break/Venue Change**	

Main Venue

13:00-13:20	**Academician Speech**	Chair: Chiaki Terashima/Shanhu Liu
	13:00-13:20	Lei Jiang (Chinese Academy of Sciences) Quantum ionics: ultra-low energy consumption of energy conversion/information transmission in biological system
13:20-14:35	**Invited Lecture**	Chair: Chiaki Terashima/Shanhu Liu
	13:20-13:35	Pailin Ngaotrakanwiwat (Burapha University) Dual-band Tunable Electrochromic Window for Climate-Responsive Buildings
	13:35-13:50	Ming Jin (Tongji University) Investigation of the Structure-Activity Relationship and Single-/Two-Photon Polymerization Properties of Double Benzylidene Ketones
	13:50-14:05	Jiannian Yao (Xi Wang)(Chinese Academy of Sciences, Beijing Jiaotong University) From Precision Chemistry to Orbital Catalysis
	14:05-14:20	Masahiro Miyauchi (Instutute of Science Tokyo) Photocatalytic Dry Reforming of Methane for Syngas Production
	14:20-14:35	Graham Dawson (Xi'an Jiaotong Liverpool University) Composite formation with titanate nanotubes for hydrogen generation
14:35-14:50	**Coffee Break**	
14:50-15:50	**Invited Lecture**	Chair: Takeshi Kondo/Zhaoyue Liu
	14:50-15:05	Weiping Qian (Southeast University) Biosensing Application of SiO_2-TiO_2 Hybrid Inverse Opal Fabry-Pérot Layers
	15:05-15:20	Kazuya Nakata (Tokyo University of Agriculture and Technology) Green conversion of biomass derived compounds to value-added chemicals
	15:20-15:35	Yanrong Zhang (Huazhong University of Science and Technology) Advanced photocatalytic technology: Electrically assisting gasphase reaction and triphase H_2O_2 synthesis
	15:35-15:50	Qingbo Meng (Chinese Academy of Sceinces) A Novel Artificial Photosynthetic System
15:50-16:10	**Academician Speech**	Chair: Takeshi Kondo/Zhaoyue Liu
	15:50-16:10	Jin Zhang(Peking University) Artificial Intelligence for Materials Science: Transforming Research Paradigms
16:10-16:20	**Closing Remarks**	

Poster Presentation

	Poster session	November 29 (Sat)	13:20–14:20
No	**Name**	**Affiliation**	**Title**
P-001	Dan Wang	Jilin Agricultural University	Surface/Interface Modification Enhances the Photoelectrochemical Water Splitting Performance of Oxide Photoanodes
P-002	Mitsuhiro Honda	Nagoya Institute of Technology	Metal Cation Doping into TiO_2 Photocatalysts via Liquid Phase Deposition for Decomposing Acetaldehyde
P-003	Zheng Ling	Shanghai Jiao Tong University	Photo-induced Minor Enantiomer Stereoinversion
P-004	Bo Zhang	Southeast University	Fabrication and Biosensing Application of SiO_2-TiO_2 Hybrid Inverse Opal Fabry-Pérot Layers
P-005	Xiaoling Zheng	Southeast University	Interference effect of tubular colloidal crystal films and their biosensing applications
P-006	Tianyang Yuan	Xi'an Jiaotong Liverpool University	MoO_3-X/COF/TiNT heterojunction photocatalyst used in photocatalysis
P-007	Qingran Chang	Xi'an Jiaotong Liverpool University	Organic scaffold and Nanomaterial synthesis for applications in photocatalytic water splitting or CO_2 reduction
P-008	Jie Xie	Tongji University	Investigation of the Structure-Activity Relationship and Single-/Two-Photon Polymerization Properties of Double Benzylidene Ketones
P-009	Wenyi Guo	Beihang University	Tandem Oppositely Charged Nanoclay Membranes with 2D Nanofluidic Channels for Osmotic Energy Conversion
P-010	Shiheng Liu	Tongji University	Ternary Hybrid Materials Based on the Photoinduced Cationic Polymerization of Functional Twin Monomer and Epoxides
P-011	Yangyang Li	Tongji University	New Water-Soluble Coumarin-Ketone-Pyridium Salts Photoinitiators for Antibacterial Coatings under Visible LED Photocuring
P-012	Shuyu Li	Beihang University	Strategies for Enhancing Osmotic Energy Conversion in 2D montmorillonite-based Nanofluidic Membranes
P-013	Xiyang Liu	Xi'an Jiaotong Liverpool University	Dual S-scheme g-C3N4/Fe_3O4/In_2O_3/MoS_2 magnetic nanocomposite for enhanced visible-light-driven tetracycline degradation
P-014	Jie Hou	Tongji University	Effects of Allyloxy Substitution on Photochemical Properties of Thioxanthones and Their Application in Visible-LED Photopolymerization
P-015	Ziyu Zhang	Southeast University	Gradient Electroactive Hydrogel Scaffolds for Wireless Electrical Stimulation-Mediated Nerve Repair
P-016	Qianxiang Su	Shanghai Jiao Tong University	Construction and Preliminary Investigation of Non Immersed Photocatalytic Hydrogen Evolution System
P-017	Rimsha Khalid	Henan University	Integrated Photothermal Evaporation and Photocatalytic Degradation/removal of Microplastics Using Titanium Mesh Supported TiO_2 Nanotube Arrays
P-018	Yanan Li	Northeast Normal University	Click Gel Polymer Electrolyte Achieving Liquid-Comparable Conductivity
P-019	Yawei Wang	Northeast Normal University	Molecular linker engineering CdS/$Cu_2ZnSn(S,Se)_4$ interface for efficient photovoltaics
P-020	Dexin Jin	Northeast Normal University	Photo-Plasma Relay Catalysis for Molecular Oxygen Activation
P-021	Tianxing Liu	Chinese Academy of Sceinces	Highly Efficient Sunlight-Driven CO_2 Hydrogenation to Methanol Over supported NiZn intermetallic catalyst on α-Al_2O_3
P-022	Chen Wang	Shanghai Jiao Tong University	Ni-doped ZnCdS in Liquid-phase Z-type reaction system for photocatalytic overall water splitting
P-023	Lei Wang	Henan University	High-performance quantum dot light-emitting diodes
P-024	Pengli Li	Southeast University	Magnetic Cilia Microreactor Array for Rapid Trace Proteomics Digestion
P-025	Yuxin Li	University of Shanghai for Science and Technology	Effect of Co-Dissolved Organic Compounds on Photocatalytic Degradation of Simetryn, Prometryn, Metolachlor, and Sulfometuron methyl
P-026	Sijie Cheng	Henan University	Design of Photothermal Interfacial Evaporation Structures Based on Porous Materials and Synergistic Mechanisms of Gradient Photothermal Management
P-027	Xiaoyan Sun	Instutute of Science Tokyo	CuO@Fe_2O_3 Nanotubes Enabling Efficient Semiconductor-Sensitized Thermal Cell via Charge Separation and Band Structure Prediction
P-028	Yuanyuan Li	Northeast Normal University	Facet-Engineered Au_1/CeO_2 Single-Atom Catalysts toward Efficient Room-Temperature Photothermal CO Oxidation
P-029	L. Chenjun	University of Shanghai for Science and Technology	The Self-Sustaining Fenton Reaction: A Biocatalytic System for In Situ H_2O_2 Generation
P-030	Jingshen Wang	University of Shanghai for Science and Technology	Easy-to-Recycle Floating PVDF/TiO_2 Piezo-Photocatalytic Spheres for Agricultural Irrigation Water Purification.
P-031	Zhuo Chen	University of Shanghai for Science and Technology	Second-scale laser-driven synthesis of defect-engineered titanium-niobium oxide anodes for advanced lithium-ion battery applications

No	Name	Affiliation	Title
P-032	Yang Fu	University of Shanghai for Science and Technology	Matter Conversion and Clean Energy Catalysis
P-033	Yuying Mao	University of Shanghai for Science and Technology	Efficient Water Treatment Using Closed-Packed Bed Type Photocatalytic Reactors
P-034	Kazuo Hosoda	University of Shanghai for Science and Technology	Photocatalytic Filters Based on Anodizing Process and Its Functional Applications
P-035	Mingyue Li	Southeast University	Predicting antitumor drug response using a deep learning model of patient-derived lung cancer organoids
P-036	Xiangyu Li	University of Shanghai for Science and Technology	Phase Transformation of TiO_2 Photocatalytic Powder: From Rutile to Anatase

Saturday, November 29, 2025

Main Venue

Keynote Speech

Academician Speech

Invited Lecture

Photocatalysis, Present Situation and Future Direction

Institute of Photochemistry and Photofunctional Materials, University of Shanghai for Science and Technology
Akira Fujishima

The tremendous amount of research that has been carried out in the two closely related fields of semiconductor photoelectrochemistry and photocatalysis during the past three decades continues to provide fundamental insights and practical applications.

The principles and measurements obtained TiO_2 with photoelectrochemical studies have led to the research activity on heterogeneous photocatalysis, where the strong photooxidative activity of TiO_2 has been applied to environmental cleanup. This resulted in the concept of "light cleaning", i.e., deodorizing, disinfection, and decontamination of air, water and surface with TiO_2 thin films and light.

Also, we reported the novel photo-induced superhydrophilicity of TiO_2 and proposed the concept of self-cleaning superhydrophilic properties of TiO_2.

Now in the world, there are potential applications of photocatalysis in various fields. Our research focuses on developing transparent anti-fogging coatings for the walls of buildings and glass for the purpose of self-cleaning and to develop efficient photocatalytic materials to purify environmental air and water . We believe that the purification of water and air is an extremely important area in the research. I will report present, some of our recent results carried out by our members.

Super Graphene-Skinned Materials: Concept, Synthesis and Applications

Zhongfan Liu

Beijing Graphene Institute (BGI) & Peking University, Beijing 100871, China

Super graphene-skinned materials describe a new type of graphene composite materials made by directly depositing continuous graphene layers on traditional materials via chemical vapor deposition (CVD) process. By growing high-performance graphene “skin”, the traditional materials are given new functionalities. The atomically thin graphene hitches a ride on the traditional material carriers to market. Beyond coating graphene powder on traditional materials, the directly-grown continuous graphene “skin” keeps its intrinsic excellent properties to a great extent, and holds the promise on future applications. Super graphene-skinned material is an innovative pathway for applications of continuous graphene films, which avoids the challenging peeling-transfer process and solves the non-self-supporting issue of ultrathin graphene film. The graphene skin almost has no influence on macroscale morphology of the supporting substrate, which leads to the high process compatibility of super graphene-skinned material in practical application scenarios. Therefore, graphene-skinned materials would exhibit their excellent performance without changing the processing of current engineering materials, and will be pushed to real industrial applications relying on the broad market of current engineering materials.

Super graphene-skinned materials can be categorized into graphene-skinned metallic materials and graphene-skinned nonmetallic materials. Depending on the different morphologies of supporting substrate materials including foil, fiber, powder, foam, etc., one can obtain graphene-skinned foil, graphene-skinned fiber, graphene-skinned powder, graphene-skinned foam, etc. Additionally, together with post-processing treatments and compositing with other materials, great versatilities can be expected for super graphene-skinned materials. A typical example is graphene-skinned glass fiber, which combines the excellent properties of graphene and glass fiber, such as the high electrical conductivity and thermal conductivity of graphene, along with the remarkable mechanical strength and flexibility of glass fiber. Graphene-skinned glass fiber presented wonderful electrothermal performances with fast heating rate and high heating uniformity, which has been successfully applied for the anti/deicing of aircraft and wind blade. The new concept of super graphene-skinned material opens up a new avenue for practical applications of continuous graphene films, strongly promotes the fusion of graphene and traditional materials, and provides new power for accelerating the graphene industry.

Biography and Research Interests:

Zhongfan Liu completed his PhD from University of Tokyo in 1990 and postdoctoral study from the same university and Institute for Molecular Science (IMS), Japan. His current research interests include the CVD growth, mass production and equipment manufacturing, and unique applications of graphene. He is the founding Director of Beijing Graphene Institute (BGI) and a BOYA chair professor of Peking University. He is the member of Chinese Academy of Sciences and the fellow of TWAS.

Membrane-based alternative to energy-intensive distillation processes

Zhiyong Tang

National Center for Nanoscience and Technology, Beijing 100190

Keywords: membrane separation, distillation alternative, organic nanofiltration, azeotrope separation, crude oil fractionation

Traditional distillation processes are extensively employed in the petroleum, chemical, and pharmaceutical industries; however, they are highly energy-intensive and costly to operate, especially for separating azeotropes and complex hydrocarbons. Membrane separation technology offers a promising alternative to distillation, with the potential to achieve significant energy savings and emission reductions. (1) Incorporating rigid molecular frameworks into membrane materials endows them with high porosity and interconnected transport channels, facilitating efficient pore-flow transport and markedly improving separation flux. (2) Constructing sub-nanometer channels via staggered stacking of self-assembled porous materials enables highly selective separation of azeotropic organic solvents (molecular weight < 200 Da) under low operating pressures, effectively bridging the gap between low-pressure nanofiltration and high-pressure reverse osmosis processes. (3) The design and fabrication of swelling-resistant and fouling-tolerant membranes allow all-liquid phase separation of complex crude oils. These membranes demonstrate exceptional long-term stability over operation periods exceeding 2000 hours, underscoring their strong potential as membrane-based alternatives to conventional crude oil distillation.

References

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2. Liang B., He X., Hou J., Li L., Tang Z., *Adv. Mater.* 2019, 1806090
3. Liu C., Hou J., Yan M., Zhang J., Alemayehu H. G., Zheng W., Liu P., Tang Z., Li L., *Angew. Chem. Int. Ed.* 2024, 63, e202320137.
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Organ-on-a-chip and Bioanalysis

Southeast University Director, State Key Laboratory of Digital Medical Engineering

Director, Institute of Biomaterials and Biomedical Devices, Yangtze River Delta National Innovation Center for Technological Sciences

Zhongze Gu

Abstract:

Microphysiological systems (MPS) represent an emerging interdisciplinary field that integrates biology, engineering, and informatics to overcome the limitations of traditional biomedical models. Rather than serving as simplified in vitro cultures, these systems recapitulate the structural, biochemical, and functional complexity of human organs, enabling precise control, dynamic observation, and full experimental intervention under physiologically relevant conditions.

As a representative platform of MPS, organ-on-a-chip technology utilizes stem cell and tissue engineering approaches to reconstruct human physiological systems on microfluidic chips. Compared with conventional cell cultures, which fail to mimic in vivo conditions, and animal models, which suffer from species differences, low throughput, and ethical concerns, organ-on-a-chip systems offer markedly improved predictive accuracy for human responses. By interconnecting multiple organ chips via microfluidic networks, a “body-on-a-chip” can be established to simulate systemic circulation and organ–organ crosstalk, providing a powerful analytical platform for systems-level bioanalysis and mechanistic studies of complex physiological and pathological processes.

The open and accessible nature of these platforms allows seamless integration with in situ and real-time analytical technologies, transforming bioanalysis from “static snapshots” to “dynamic movies.” This drives innovation in miniaturized, integrated, and multimodal sensing technologies capable of multi-parameter detection, facilitating model validation and mechanistic discovery. In application, organ-on-a-chip technologies have greatly advanced drug development and precision medicine: standardized iPSC-derived models enable accurate preclinical assessment of pharmacodynamics, pharmacokinetics, and organ toxicity, while patient-specific disease models support individualized drug guidance and elucidation of disease mechanisms and therapeutic targets.

Electrochemical CO_2 reduction by boron-doped diamond electrodes

Department of Chemistry, Keio University
Yasuaki Einaga

Boron-doped diamond (BDD) electrodes are attractive materials owing to their wide potential window, low background current, chemical inertness, and durability.[1] We have reported various electrochemical sensor applications, including microsensing systems for *in vivo* real-time drug kinetics,[2] as well as uses in organic synthesis[3] and electrochemiluminescence.[4] Here, recent progress in electrochemical CO_2 reduction with BDD electrodes is outlined.

In 2018, CO_2 reduction in a flow cell with BDD electrodes achieved a faradaic efficiency (FE) of 94.7% and >99% selectivity for HCOOH.[5] In 2019, we demonstrated switchable product selectivity: CO production was favored using 1% boron-doped BDD with $KClO_4$, whereas 0.1% boron and KCl led predominantly to HCOOH.[6] Recently, a piston-driven intermittent flow system was developed, markedly enhancing CO_2-to-HCOOH conversion compared with continuous flow.[7] We also discovered a "self-activation" effect, where initial electrolysis improved current and FE.[8]

To address long-term stability, we studied ion transport in the electrolyte. Controlling ion concentrations enabled stable formic acid production for an exceptionally long duration (1,264 h).[9] These findings highlight both the tunability and scalability of BDD electrodes for CO_2 electroreduction.

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Surface Design of Advanced Photocatalysts for Energy and Environmental Applications

Key Laboratory of UV-Emitting Materials and Technology, Northeast Normal University
Xintong Zhang

The surface of photocatalysts plays as site where photocatalytic reactions occur, and influences the reaction pathways and even the charge recombination in a significant way.[1] Rational design of the surface is therefore essential for advanced photocatalysts, especially for energy photocatalysis that multi-electron processes are often involved.[2] In this talk, I will present our research works on the surface modification of TiO_2 and CeO_2 photocatalysts, focusing on the impact of surface amorphorization and single-atom catalysts. We show that surface amorphorization of TiO_2 photocatalysts, induced by ultrasonics,[3] and solution discharging plasma,[4] respectively uplifts the surface electronic states and prolongs the charge separation, and consequently enhances the performance of photocatalytic hydrogen evolution. The surface amorphorization of TiO_2 can reduce the particle size of the photo-deposited Pt cocatalysts and remove high-valence Pt species, and as a result promote the photothermocatalytic conversion of CO_2 to methane.[5] On the other hand, we prepare noble metal single/dual atom catalysts on CeO_2 nanosheets by solution plasma processing. The resultant Au_1/CeO_2 photocatalyst displays a 1.7% conversion rate in CO catalytic oxidation at room temperature by a photo-enhanced M-vK pathway.[6] We further developed a continuous-flow plasma process, enabling rapid synthesis of various single/dual-atom noble metal loaded CeO_2. Under Xe lamp irradiation, Au_1Rh_1/CeO_2 breaks room temperature constraints in CO conversion for the water–gas shift reaction with a T50 (the temperature at which 50% CO conversion occurs) of 298 K.[7]

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Red Light-Inducible Solid-State Z-Scheme Photocatalysts for Overall Water Splitting and Carbon Dioxide Reduction with Water Oxidation

Clean Energy Research Center, University of Yamanashi
Hiroshi Irie

Since Fujishima and Honda reported photoelectrochemical water splitting using a titanium dioxide (TiO_2) electrode in 1972 [1], solar hydrogen (H_2) production from water using a photocatalyst has attracted attention as a clean energy resource. Most recent research has been focusing on the visible-light sensitization of catalysts to effectively utilize solar energy.

Our research group has developed a solid-state hetero-junction photocatalyst, silver (Ag) inserted zinc rhodium oxide ($ZnRh_2O_4$ (ZRO), bandgap energy (E_g) of 1.2 eV) and bismuth vanadate ($Bi_4V_2O_{11}$ (BVO), E_g of 1.7 eV), denoted as ZRO/Ag/BVO, where Ag, ZRO, and BVO act as a redox mediator, H_2-evolution photocatalyst, and oxygen (O_2)-evolution photocatalyst, respectively [2,3]. Overall water splitting, producing H_2 and O_2 simultaneously from water at a stoichiometric ratio 2:1, was accomplished using ZRO/Ag/BVO irradiated with red light at wavelengths of up to 740 nm. We selectively loaded copper (Cu) and cobalt oxide (CoO_x) as cocatalysts for the reduction reaction onto ZRO and the oxidation reaction onto BVO, respectively, in ZRO/Ag/BVO to form Cu/ZRO/Ag/BVO/CoO_x. Cu/ZRO/Ag/BVO/CoO_x accomplished overall water splitting, enhancing the stoichiometric productions of H_2 and O_2 from water compared with bare ZRO/Ag/BVO. The optimized Cu/ZRO/Ag/BVO/CoO_x photocatalyst was confirmed to reduce CO_2 to methane, simultaneously producing O_2, using water as an electron donor and proton source under irradiation with visible light at a wavelength of 700 nm [4,5]. This is, to our knowledge, the longest wavelength reported to date for CO_2 reduction.

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Construction of multi-chambered mesoporous nanoreactors

College of Energy Materials and Chemistry, Inner Mongolia University, Hohhot, P. R. China.

Yuzhu Ma

Abstract

Hollow nanoreactors exhibit competitive potentials in heterogeneous catalysis due to their tailorable microenvironment effects, in which the multi-chambered architectures have attracted much attention, but manipulating the chamber numbers and coupling multi-functionality is still a challenge. Herein, we propose a nanodroplet remodeling strategy to synthesize hierarchical multi-chambered mesoporous silica nanoparticles with structurally tunable structures by cleverly exploiting the dynamically tunable properties of emulsion templates to achieve droplet epitaxy, sunken, merge, and swell at the single-droplet level. We adopt a dynamic migration strategy of emulsion droplet interface to fabricate tadpole-shaped asymmetric mesoporous single-cavity silica nanomotors with low drag coefficients and directional motion characteristics. The nanodroplet sunken strategy is adopted to precisely regulate the convex-concave degree of nanoreactors using solvents with different polarities to explore the structure-activity relationship between the spatial confinement effect of the nanoreactors with different curvatures and the photothermal catalytic performance. Subsequently, we employ the nanodroplet swell strategy to design two large-cavity mesoporous nanoparticles interconnected like a calabash. Furthermore, an in situ partitioned co-assembly strategy is developed to construct a bifunctional nanoreactor. The separation and localization of multifunctional components in different cavities are verified to achieve the stability of multifunctional components while avoiding mutual crosstalk when they are independently loaded in different spatial positions of asymmetric mesoporous nanoparticles. Recently, we reported a nanodroplet merge strategy for assembling anisotropic mesoporous silica nanoparticles into branching superstructures. A multi-branched nanotree is constructed by adding palladium nanocrystals as binders fusing droplets on one side of the pre-formed nanoparticles to a Y-shaped dimer and further extending the Y-structure to a multilevel branching structure through subsequent sequential fusion growth. These classic cases are eagerly expected to provide unique strategies and broad insights for designing different novel asymmetric multi-cavity nanoreactors and provide theories and experimental bases for expanding their applications in the field of efficient multi-functional co-catalysis.

Biography:

Professor Yuzhu Ma

Professor and Doctoral Supervisor at Inner Mongolia University, Distinguished Young Changjiang Scholar of the Ministry of Education, China. His research focuses on the design of novel porous materials and the construction of nano-reactors. He pioneered innovative concepts such as droplet interface assembly and multi-chamber confined nano-reactors, systematically investigating the structure-performance relationships in catalytic applications. His groundbreaking work has been published in top-tier journals including *Nat. Nanotechnol.*, *Nat. Rev. Chem.*, *Nat. Synth.*, and others, with over 20 high-impact papers. His contributions to materials science have earned him prestigious accolades such as the Inner Mongolia Youth Science and Technology Talent Award, Young Top-notch Talents of Inner Mongolia Autonomous Region.

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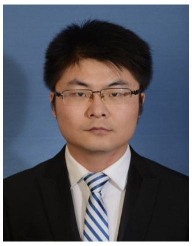
Efficient Removal of Organic Pollutants from Water by Fenton-like Processes



School of Materials and Chemistry, University of Shanghai for Science and Technology
Zichao Lian

Pursuing the "Dual-Carbon" Goals, China is home to the world's largest chemical industry. This sector, however, is characterized by the enormous volume and broad distribution of its wastewater, as well as the complex composition of the organic pollutants it contains. It accounts for 2.5% of the country's total carbon emissions, while China's overall carbon footprint from wastewater treatment ranks first globally. As a result, the treatment of organic pollutants in industrial wastewater has become a matter of critical importance. Among various available technologies, photocatalytic oxidation demonstrates considerable potential for the advanced removal of these organic contaminants. The photocatalytic process involves three fundamental steps: light absorption, photoinduced charge separation, and surface redox reactions. The efficiency of the charge separation step is pivotal to the overall photocatalytic performance. Therefore, developing effective strategies to enhance this separation efficiency has emerged as a vital research direction for the advanced treatment of organic pollutants in wastewater, contributing to water pollution control and resource recovery, and attracting extensive research interest.

Nevertheless, the application of photoinduced charge separation for degrading organic pollutants in wastewater faces several bottleneck challenges, including low efficiency, short charge carrier lifetime, and the difficulty in achieving spatial separation of redox reactions. To address these issues, the applicant has identified enhancing photoinduced charge separation efficiency for the removal of organic pollutants from industrial wastewater as a key research focus in the field of water pollution control chemistry. A series of fundamental and applied research initiatives will be undertaken to explore this promising pathway.[1-7]

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Saturday, November 29, 2025

1st Venue

Invited Lecture

A new thermal energy conversion technology : Semiconductor-sensitized thermal cell”

Institute of Science Tokyo, Japan.　elleThermo, Ltd, Japan.
Sachiko Matsushita

In recent years, novel heat-to-electricity conversion technologies have been emerging. In this context, we propose and investigate a new concept of semiconductor-sensitized thermal cell (STC)[1], in which thermally excited charges in semiconductors drive redox reactions of electrolyte ions to produce electricity. The proposed STC is inspired by the operating principle of dye-sensitized solar cells (DSSCs).

In a DSSC, photoexcited electrons in the dye are transferred to the electron transport layer and then to the counter electrode, where they reduce electrolyte ions. The remained hole in the dye subsequently oxidized the reduced electrolyte ion, resulting in a continuous electron circulation that produces an electric current. Inspired by these systems, we propose an STC in which thermal excitation of the semiconductor replaces dye photoexcitation. In this scheme, thermally excited electrons circulate between the working electrode, counter electrode, and electrolyte in an analogous manner, thereby enabling heat-to-electricity conversion.

The operating principle of the STC was demonstrated using sensitized cells fabricated with organic perovskite semiconductors[2] and silver sulfide semiconductors[3], which generated electricity from both light and heat. Furthermore, it was shown that the STC reaches equilibrium and ceases discharging after continuous operation for an extended period. However, when the circuit is switched off and left to rest, the cell can discharge again, indicating that as long as heat is supplied, continuous power generation can be achieved by repeatedly switching the circuit on and off[4].

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Anisotropy-Driven Charge Spatial Vectorial Separation and Migration

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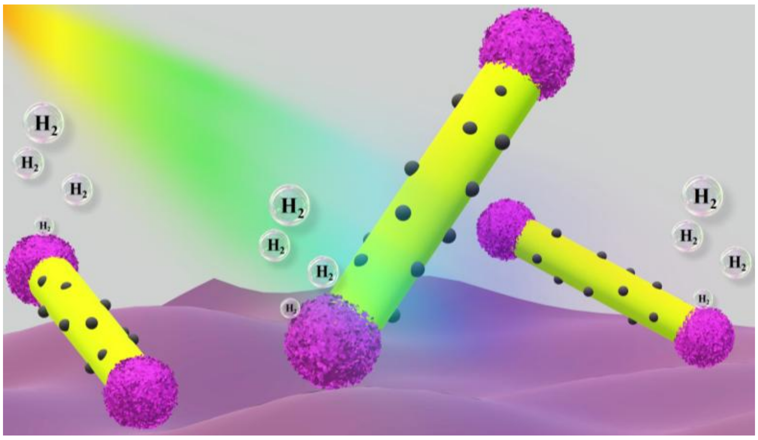
Teng Li, Zhiliang Jin*, Noritatsu Tsubaki*

Tailoring advanced anisotropy-driven efficient spatial separation and migration of photogenerated carriers is a pivotal stride toward enhancing photocatalytic activity. Here, CdS-MoS_2 binary photocatalysts are tailored into a dumbbell shape by leveraging the rod-shaped morphology of CdS and employing an in situ tip-induction strategy. To further enhance the photocatalytic activity, an in situ photo-deposition strategy is incorporated to cultivate MnO_x particles on the dumbbell-shaped CdS-MoS_2. Benefiting from its robust activity as a reduction active site, MoS_2 adeptly captures photogenerated electrons, facilitating the reduction of H^+ to produce hydrogen. The hydrogen evolution rate of 35MnO_x-CdS-MoS_2-3 surpasses that of CdS by nearly an order of magnitude, achieving a quantum efficiency of 22.30% at 450 nm. Under simulated solar irradiation, it attains a rate of 42.86 mmol g^{-1} h^{-1}. This work imparts valuable insights for the design of dual co-catalysts, anisotropy-driven spatial vectorial charge separation and migration, and the analysis of migration pathways of photogenerated carriers.



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Photocatalytic H_2O_2 Generation in Hydrogel-Sustained Benzyl-Integrated Frameworks for Solar Disinfection

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Wenjuan Zhang, Gang Liu, and Dayang Wang

Covalent organic frameworks (COFs) are emerging photocatalysts owing to their molecular-level tunability. Here, we report a structurally simple, non-conjugated class—benzyl-integrated frameworks (BIFs)—synthesized via a one-step Friedel–Crafts reaction from benzene and dichloromethane. Despite lacking extended π-conjugation, BIFs exhibit strong photoluminescence and photovoltaic response arising from transient-state bipolarization, enabling efficient redox conversion of H_2O and O_2 into H_2O_2 with maximal production rates of ~3.8 $mmol \cdot g^{-1} \cdot h^{-1}$ under visible light and ~1.0 $mmol \cdot g^{-1} \cdot day^{-1}$ under sunlight. To suppress aggregation and improve performance in aqueous media, BIFs were immobilized in agar hydrogels using DMSO as an intermediate medium, achieving a 1.3-fold enhancement over powder catalysts. The resulting hydrogel beads served as column fillers to construct a continuous H_2O_2 generation reactor, enabling rapid, solar-powered water disinfection. This work uncovers the untapped potential of non-conjugated COFs in practical photocatalysis.

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Practical Evaluation Methods of Photocatalyst from Dialogue with the Industry

Kanagawa Institute of industrial Science and TEChnology (KISTEC), KSP, 3-2-1 Sakado, Takatsu-ku, Kawasaki, Japan
Tsuyoshi Ochiai, Kengo Hamada

Now we propose a comprehensive review of our recent contributions to the field of photocatalytic environmental purification. As a public research institute, our studies have focused on the practical evaluation of photocatalytic materials informed by the fundamental principles of photocatalysis and ongoing dialogue with industry partners.

Our first study introduced the synergistic interactions between photocatalysis, ozone treatment, and metal catalysts in the decomposition of acetaldehyde[1]. Metal catalysts facilitated the initial oxidation of acetaldehyde, while photocatalysis accelerated subsequent stages, including the mineralisation of intermediates. Ozone contributed additional reactive oxidative species, further enhancing decomposition rates.

On the other hand, we developed a novel screening test to assess the anti-viral performance of photocatalytic materials against SARS-CoV-2[2]. This method provides a rapid and efficient means to evaluate the anti-viral capabilities of photocatalysts, which is particularly relevant in the context of the ongoing COVID-19 pandemic. The proposed screening test, based on the ‘acetaldehyde decomposition test’, offers a correlation between air purification efficiency and viral inactivation, providing a promising tool for rapid evaluation of photocatalytic materials.

These studies underscore our commitment to advancing the application of photocatalysts in environmental purification, bridging the gap between laboratory research and real-world applications. By establishing practical evaluation methods and engaging in productive industry dialogue, we aim to contribute significantly to the development of sustainable and effective environmental purification technologies.

Acknowledgments

The first study was conducted as a commissioned technical development undertaking requested by Mr. Michifumi Okui (Fuji Industrial, Co., Ltd.).

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In-liquid Plasma-engineered Titanium Dioxide Photocatalyst with Enhanced Performance in Environmental Purification

Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science, Chiba, Japan
Chiaki Terashima

Titanium dioxide (TiO_2) is widely used as a photocatalyst due to its chemical stability, abundance, biocompatibility, and environmental advantages. However, its wide band gap limits activity to the UV region, and rapid electron–hole recombination reduces photocatalytic efficiency under sunlight. Strategies to overcome these limitations include one-dimensional nanostructures (nanotubes, nanofibers, nanorods) to suppress recombination, heterojunction formation with other semiconductors to enhance charge separation, and modification with gold clusters to extend light absorption into the visible and near-infrared regions. Black TiO_2 nanoparticles can narrow the band gap, but require harsh conditions such as treatment in 2 MPa hydrogen at 200°C for five days (X. Chen et al., *Science*, 331 (2011) 746). Conventional hydrogenation methods, including thermal and plasma treatments, often involve high temperatures (>1,000°C), vacuum systems, long processing times, and post-treatment crushing, highlighting the need for alternative approaches that maintain nanoscale particle size.

Non-equilibrium plasma, where electron temperature greatly exceeds ion temperature, provides a low-temperature reaction environment suitable for material synthesis. In-liquid-phase plasma allows reactions below the solvent boiling point, creating unique reaction conditions. In solution plasma using a bipolar pulse power supply (O. Takai, *Pure Appl. Chem.*, 80 (2008) 2003), plasma generated in water under an air-fed environment enables surface modification of TiO_2 nanoparticles, introducing oxygen vacancies while preserving nanoscale size, enhancing photocatalytic activity (S. Pitchaimuthu, C. Terashima et al., *ACS Omega*, 3 (2018) 898). In this study, pristine TiO_2 nanoparticles were treated in a water-based plasma discharge, and their structural properties and photocatalytic performance for organic decomposition were evaluated.

Advancing Solar-to-Fuel Conversion through Innovative Photocatalyts Design

School of Materials and Chemistry, University of Shanghai for Science and Technology

Jinchen Fan

The critical challenges of rapid charge recombination and limited light absorption in solar-to-fuel conversion are addressed through innovative material designs. This work presents strategic approaches to enhance charge separation and activity. We demonstrate that constructing heterojunctions, such as in CdS-fullerene/graphene and S-scheme Mo-$ZnIn_2S_4/NiTiO_3$, enables ultra-fast electron transfer and hole trapping, significantly boosting visible-light H_2 production. Furthermore, defect engineering and synergistic junctions are leveraged to tailor electronic structures and surface reactivity. This is exemplified by using sulfur vacancies as electron reservoirs, a ferroelectric $SrTiO_3$ interlayer for stable charge separation, and a Z-scheme black phosphorus/MoO_{3-x} heterostructure for broad-spectrum light harvesting. These design principles provide a versatile toolkit for developing highly efficient and stable photocatalysts and photoanodes for H_2 evolution and CO_2 reduction.

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Alternative Evaluation Methods for Photocatalytic Air Purification Performance: Modified Resazurin Ink and Fluorescence Probe Tests

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Kengo Hamada, Daichi Minami, Misa Nishino, Tsuyoshi Ochiai

Evaluating photocatalytic air purification performance typically requires complex gas decomposition tests with expensive analytical equipment and lengthy testing periods[1]. This study investigated alternative evaluation methods using resazurin (Rz) ink techniques as substitutes for conventional acetaldehyde decomposition testing. TiO_2 films with varying performance levels were fabricated by controlling slurry concentration and spin-coating conditions. Six different samples were prepared using undiluted to 10-fold diluted TiO_2 dispersions at spin speeds of 1000-4000 rpm. Film thickness ranged from 70 nm to 1820 nm, with all samples showing porous structure formation. X-ray diffraction analysis confirmed pure anatase phase formation in all synthesized films. Cross-sectional SEM observations revealed that thicker films exhibited higher photocatalytic activity.
Conventional ISO-standardized Rz ink showed rapid color changes for high-performance materials, with complete decolorization occurring within 10 seconds during spin-coating application. This limited its applicability for quantitative evaluation of high-performance photocatalysts. Our modified-pH Rz ink (pH 12.7) enabled controlled reactivity by maintaining blue color for over 1 hour after application, even on the most active samples. The modified Rz ink method allows quantitative evaluation within five minutes through monitoring color change rates under UV irradiation. Strong correlation was observed between the Rz color change rate and acetaldehyde decomposition rate constants (R^2 = 0.91). The pH modification likely reduces the redox potential of resazurin, enabling controlled reaction rates suitable for high-performance material evaluation. Additionally, OH radical generation was measured using disodium terephthalate fluorescence probe techniques. This method showed excellent correlation with photocatalytic activity (R^2 = 0.98), providing a simpler alternative to conventional ESR measurements. These alternative methods provide practical screening tools for photocatalytic material development and quality control applications[2].

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Engineering $BiVO_4$-Based Photocatalysts for Overall Water Splitting

Research Center for Combustion and Environmental Technology,
Shanghai JiaoTong University)
Zhi Jiang, Wenfeng Shangguan

This study demonstrates a progressive strategy for developing $BiVO_4$-based photocatalysts for overall water splitting, advancing from direct band engineering to sophisticated Z-scheme system design. Initially, we synthesized a series of rare earth-doped bismuth vanadate solid solutions $Bi_{0.5}RE_{0.5}VO_4$ (RE = La, Y, Sm, Eu) through systematic band engineering, achieving photocatalytic overall water splitting with simultaneous H_2 and O_2 evolution[1]. Recently, we further explored its application as an oxygen evolution photocatalyst (OEP) by introducing Co as a structural directing agent to create additional structural asymmetry. This structurally optimized Co-$BiVO_4$ was successfully integrated with CdS to construct a efficient and stable Z-scheme photocatalytic system[2], extending the light absorption to the visible region and enabling visible-light-driven overall water splitting. This progression from single-component band engineering to dual-component Z-scheme architecture highlights the evolving design principles for $BiVO_4$-based photocatalysts, offering a comprehensive roadmap for developing efficient solar water splitting systems.

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Water Treatment using Photocatalysts in a Dispersion System Readily Separable from Water

Institute of Photochemistry and Photofunctional Materials, University of Shanghai for Science and Technology
Manabu Kiguchi, Nobuhiro Hanada, Li Yuxin, Akira Fujishima

Water treatment with photocatalysts have attracted wide attention, because it can decompose persistent substances (e.g. herbicides, dyes) that cannot be decomposed by other methods. Meanwhile, the liquid phase photocatalytic reaction is generally difficult compared to the gas phase reaction, due to low molecular diffusion in solution. A nano-sized photocatalyst suspension is an ideal system, but, the separation of the nano-sized photocatalysts from water is a subject and hinders practical application. One solution is to use fixed beds. Another solution is a dispersion system with designed photocatalysts. Here, we report two type of photocatalyst in a dispersion system readily separable from water. The first one is sub-millimeter scale photocatalysts, where photocatalysts can be separated with metal filter [1]. We prepared the TiO_2/SiO_2/polystyrene beads photocatalysts. Its specific gravity is slightly higher than 1. Thank to low specific gravity, the photocatalysts can drift in water by small perturbation. The second one is nano sized magnetic photocatalysts, where photocatalysts can be separated with magnet [2,3]. We prepared 20nm scale TiO_2-SiO_2/Fe_3O_4 photocatalysts. These two type of photocatalysts were successfully utilized for herbicide degradation and photokilling of gram positive bacteria [1-3].

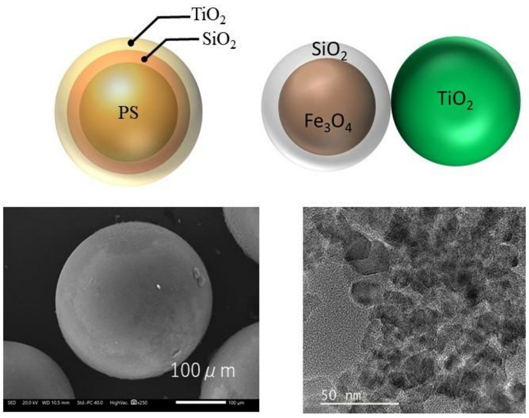

Fig: Sub-millimeter scale photocatalysts, Nano sized magnetic photocatalysts.

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Saturday, November 29, 2025

2nd Venue

Invited Lecture

Designing carbon supported metal nanoelectrocatalysts using the *d* charge descriptor

Institute of School of Materials and Chemistry, University of Shanghai for Science and Technology
Yafei Sun, Ying wan

Precise catalysis drives breakthroughs in energy and chemical conversion by enabling atomic-level control over reaction pathways[1]. Our research develops mesoporous confined catalysts, using experimentally measurable *d*/*p*-electron charges as descriptors to guide design[2-3]. By tuning local coordination and constructing ordered mesoporous frameworks, we modulate active-site electronic structures, achieving catalysts with optimized mass transport, minimal bond rearrangement, shorter reaction pathways, and reduced carbon emissions.

For example, We found that a catalyst composed of Pd nanoparticles supported by ordered mesoporous carbon (Pd/OMC) had a high reaction rate in the sulfur reduction reaction (SRR), and a Li-S battery assembled with this catalyst had a low shuttle constant of 0.031 h^{-1} and a high-rate performance with a specific capacity of 1527 mAh g^{-1} at 0.1 C which is close to the theoretical value. The high activity of Pd/OMC with a *d*-orbital vacancy of 0.87 e was predicted from a volcano relationship between the *d* charge for the metal and the adsorption activation entropy and reaction rate for the SRR by examining Pd, Au, Pt, Rh, and Ru transition-metal nanocatalysts. The strategy of using a single electronic structure descriptor to design high-efficiency SRR catalysts has suggested a way to produce practical Li-S batteries[4].

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Brightening the microcrystals of photofunctional metal complexes by light-harvesting energy transfer

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Yu-Wu Zhong

Luminescent nano/micro molecular crystals with well-defined shapes and morphologies have exhibited great potentials for photonic applications. Light-harvesting energy transfer (LHEnT) is a vital process in natural photosynthesis, the mimic of which provides a simple and practical means for solar energy conversion and the preparations of luminescent materials. I will present in this talk our recent research progress on the use of octahedral iridium (Ir^{III}) and ruthenium (Ru^{II}) complexes to prepare luminescent crystals for potential applications in nanophotonics. By introducing simple substituents on the coordination ligands, such as methyl group, fluoro atom, and trifluoromethyl group, as the functional unit to direct assembly, we have been able to obtain well-defined nano/micro crystals from these complexes.[1] Furthermore, by using a molecular doping strategy accompanied with the LHEnT process, the obtained binary crystals show efficient and tunable luminescence properties.[2] Molecular crystals with high-performance linearly polarized luminescence, circularly polarized luminescence, and electrochemiluminescence have been prepared, and their applications in polarized light waveguide and chemical sensing have been demonstrated.[3] By using a stepwise binary assembly method, optical heterostructures are prepared to show their potential in optical information processing and thermosensing.[4]

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Colloidal Synthesis of Less-Toxic Bismuth-Based Multinary Quantum Dots for Photovoltaics

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Quantum dots (QDs) are semiconductor nanocrystals (<10 nm) with size-dependent optical properties due to quantum size effects. Conventional binary QDs such as CdTe and PbS have been extensively studied for imaging, photovoltaics, photocatalysis, and LEDs, but their use is restricted by toxic heavy metals such as Cd and Pb.[1] Ternary $AgBiS_2$ QDs have recently emerged as environmentally friendly materials with strong absorption from the visible to near-infrared (NIR) regions.[2] Here, we report a solution-phase synthesis of $AgBiS_2$ QDs and evaluate their structural and photoelectrochemical properties for the application to quantum dot-sensitized solar cells (QDSSCs).[3]

$AgBiS_2$ QDs were synthesized by heating bismuth acetate, silver acetate, and elemental sulfur in a mixture of 1-dodecanethiol and oleylamine at 373–473 K for 30 min. The purified QDs were deposited on mesoporous TiO_2 and coated with CdS via successive ionic layer adsorption and reaction (SILAR). Sandwich-type QDSSCs were fabricated with Cu_xS counter electrodes and an aqueous S^{2-}/S_x redox species.

The QD size increased from 2.6 to 8.1 nm with an increase in heating temperature, leading to a narrowing of the bandgap from 1.45 to 1.05 eV, which remained larger than that of bulk $AgBiS_2$ (0.80 eV) due to the quantum size effect. XRD measurements confirmed that the resulting $AgBiS_2$ QDs crystallized in a cubic crystal structure despite their non-stoichiometric composition, with the Ag/Bi ratio increasing at higher synthesis temperatures. Photoemission yield spectroscopy in air (PYSA) revealed that the valence band maximum (VBM) shifted from –5.3 to –5.0 eV, whereas the conduction band minimum (CBM) remained nearly constant at –4.0 eV.

Photoelectrochemical measurements showed a transition from n-type to p-type semiconductor behavior with increasing synthesis temperature. The photocurrent onset approached the VBM as the synthesis temperature increased, suggesting a reduction in the density of intragap states. QDSSCs based on QDs synthesized at 423 K exhibited the highest performance, with a visible–NIR response and a power conversion efficiency of 0.76%.

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Organic photoelectrochemical energy storage materials

Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences

Xiang Zhang, **Yaobang Wang**

As an emerging technology for solar energy utilization, coupled solar batteries use photoelectrochemical materials with light harvesting and redox activity as cathode to realize direct solar-electrochemical storage via photo-coupled ion transfer (PCIT).[1-2] This thesis focuses on the controlled synthesis of organic photoelectrochemical materials as well as the design and assembly of novel coupled solar batteries, uses covalent organic frameworks (COFs) with electron donor-acceptor units as photoelectrochemical storage materials to promote the coupling between photogenerated charges and redox reactions through efficient charge separation, thereby improving the light-to-electrochemical energy storage efficiency of coupled solar batteries.[3] In this thesis, a novel coupled solar battery is designed, in which the COF-based photoelectrochemical energy storage cathode and anode couple two PCIT reactions, based on the photo-intercoupled electron-ion transfer (PIEIT) mechanism, ultimately achieving a record photoelectric conversion efficiency (6.9%) and large scale solar-to-electrochemical energy storage, demonstrating that coupled solar batteries have great potential for practical applications.[4-5]

Key words: Coupled solar batteries, Covalent organic frameworks, Charge transfer, Redox reaction.

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Photocatalytic Disinfection of Water: Our Recent Study and Future Direction

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Nobuhiro Hanada, Manabu Kiguchi, Yoshiaki Nomura,
Akira Fujishima

Biofouling of reverse osmosis (RO) membranes is a significant problem in water treatment, causing performance deterioration and reduced lifespan. Chlorination is effective but unsuitable for polyamide RO membranes due to their chlorine sensitivity. To address this issue, a magnetically recoverable TiO_2–SiO_2/Fe_3O_4 photocatalyst was synthesized and evaluated under UV-A and UV-C irradiation. *Lactobacillus casei* served as a safe model microorganism for rapid disinfection assessment based on turbidity measurement. The process followed pseudo–first-order kinetics and completely inactivated *L. casei* within 50 minutes under UV-A irradiation.

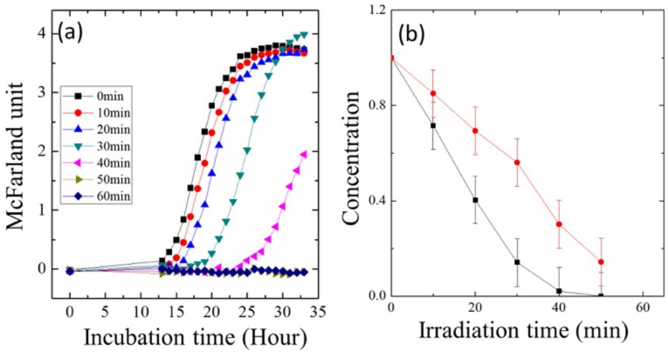

Figure: Bactericidal effect of TiO_2–SiO_2/Fe_3O_4 photocatalyst. (a) McFarland unit of the L. casei solution as a function of incubation time at different UV irradiation times. (b) Concentration of viable bacterial cells before incubation as a function of UV irradiation time, with and without photocatalysts. (Kiguchi et al. 2025)

While UV-C irradiation rapidly induces pyrimidine dimer formation in microbial DNA, repair enzymes can reverse this damage. Therefore, combining UV-C pre-irradiation with UV-A/TiO_2 photocatalysis effectively suppresses these enzymatic repair mechanisms and prevents bacterial regrowth. This study proposes a multistage disinfection system integrating UV-C pre-irradiation with UV-A/TiO_2 photocatalysis as a sustainable approach for water treatment.

Preventing biofilm formation on RO membranes through the synergistic effects of DNA damage and repair enzyme inactivation is essential for maintaining long-term membrane performance. This photocatalytic disinfection strategy has broad potential for protecting RO membranes in agricultural, medical, and semiconductor water purification systems.

Strategies for Inert Molecule Conversion: From Electrochemical CO_2 Reduction to In-liquid Plasma-Based Nitrogen Fixation

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During electrochemical CO_2 reduction reaction (eCO_2RR), both current density and Faradaic efficiency on boron-doped diamond (BDD) electrodes were markedly enhanced, an effect termed BDD self-activation. Unidentate carbonate and carboxylic groups were identified as intermediates, with gradual weakening of the C=O bond leading to formic acid formation. Long-term CO_2 electrolyzer tests for formic acid showed an electrical-to-chemical energy conversion efficiency of 50.2% after self-activation.[1]

Sustainable nitrogen fixation is vital for agriculture and chemical production but remains constrained by trade-offs between energy demand and efficiency. Low-barrier routes cannot cleave the strong N≡N bond (945 kJ mol^{-1}), while high-energy methods suffer from product decomposition. We report an in-water plasma system integrating W, Al, and Fe electrodes to activate pulsed discharge plasma, enabling efficient nitrogen dissociation and selective formation of soluble species (nitrate, nitrite, ammonia). The system achieves 1.14 MJ mol^{-1} energy consumption and a production rate of 12.9 mmol h^{-1} cm^{-2}, surpassing other aqueous methods and approaching Haber-Bosch performance. this carbon-neutral, electricity-driven method provides a sustainable path for decentralized agriculture and chemical manufacturing.[2,3]

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Lithium-mediated electrochemical ammonia synthesis via the catalytic solid–electrolyte interphase

Zongjing Lu

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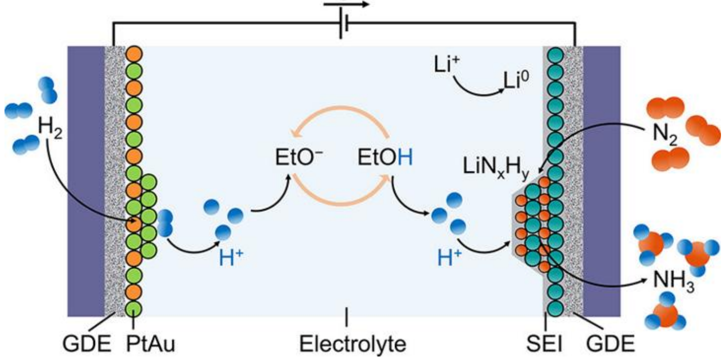

Lithium-mediated electrochemical nitrogen reduction for ammonia synthesis represents the most industrially viable electrochemical nitrogen fixation system. This process bypasses nitrogen triple bond activation. Reactive lithium metal directly reacts with nitrogen to form lithium nitride. The lithium nitride is then protonated to produce ammonia at the cathode interface. However, during the reaction, the formation of a solid electrolyte interface (SEI) due to the interaction between the electrolyte and reactive lithium metal, as well as spontaneous decomposition, impedes the diffusion of N_2, H^+, and Li^+, thereby reducing the catalytic performance of lithium-mediated ammonia synthesis [1, 2]. To address this, the key to enhancing the intrinsic activity of lithium-mediated ammonia synthesis lies in regulating the composition of the SEI to improve the reaction kinetics of reactants traversing the SEI. Specifically, LiF formed from F^- and Li^+ reactions enhances Li^+ surface mobility. This effect improves lithium deposition uniformity and reduces migration barriers for N_2 and H^+. Incorporating LiF into the SEI significantly enhances reaction performance. It boosts selectivity, kinetics, and stability [2-5]. This study constructs highly polarized interfacial layers where semi-ionic C-F bonds with strong polarization enhance the electronegativity at the interface, accumulating spin-polarized electrons in metal nanoparticles. This improves the electrochemical interaction between Li^+ and the carbon matrix, significantly promoting LiF formation. Building on this, a surface oxygen vacancy strategy is proposed to induce phase transition in ferroelectric materials, enabling ordered surface dipole alignment and selective anion adsorption, thereby enhancing lithium-mediated ammonia synthesis performance [5].

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Facile Immobilization of Powdered Photocatalyst for Fabricating Self-Suspended Photocatalytic Millimeter-Sized Spheres (MSSs)

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Abstract

Transforming powders non-destructively into macroscopic materials offers immense scientific and application potential through versatile structural and functional design, yet conventional methods struggle to achieve this. Herein, we developed a simple and universal method for immobilizing powder catalysts. By leveraging the unique properties of polyvinylidene fluoride (PVDF), various powder materials were successfully transformed into millimeter-sized photocatalytic spheres, which provide structural support while preserving the intrinsic characteristics and structure of the photocatalysts. The study revealed that hydrophobic interactions, surface tension, and metal–F bond interactions collectively induce the expansion and contraction of PVDF and the supported powder particles, maintaining them as millimeter-sized spheres through a mild process. This approach effectively prevents particle aggregation and structural damage. We demonstrated the methodology with multiple powdered catalyst samples and fabricated photocatalytic spheres tailored for different aqueous environments. To eliminate the energy barrier associated with mechanical stirring during the photocatalytic degradation of organic wastewater, self-suspending photocatalytic spheres have been developed. These spheres establish autonomous buoyancy without mechanical agitation, requiring small size, lightweight, and a density close to that of water for optimal performance. Our self-suspending photocatalytic sphere strategy offers a universal, straightforward, and non-destructive pathway to bridge powdered particles with macroscopic applications.

Exploration of the eXtended ONIOM (XO) Method for Highly Accurate DFT Calculation of NMR Shifts

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Zhipeng Ke[1], Jingwei Weng[2], Xin Xu[2]*

Nuclear Magnetic Resonance (NMR) spectroscopy serves as a powerful tool for probing the electronic environments surrounding atoms within a molecular system. Its synergy with X-ray diffraction facilitates the investigation of complex structures. However, probing the systems having unpaired electrons presents formidable challenges[1]. In this study, we introduce and explore the eXtended ONIOM (XO) method[2] for NMR calculations, as illustrated in Figure 1. The XO method is developed to compute diamagnetic and paramagnetic ^{13}C chemical shifts, exhibiting convergence with high-fidelity traditional electronic structure computations while imposing modest computational demands[3]. Our investigation encompasses diverse fragmentation schemes, advanced DFT functionals, and basis sets to assess their impacts on computational accuracy. Presently, the XO method finds successful application in characterizing the NMR parameters of both diamagnetic large molecules and paramagnetic Co(II) porphyrin complexes. This endeavor establishes a foundational framework for leveraging the XO method in elucidating the NMR parameters of complex systems and unraveling their underlying properties.

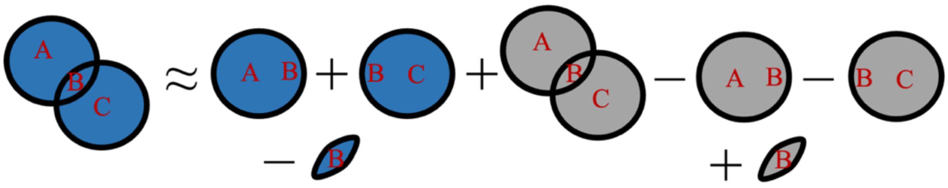

Fig. 1 Schematic of two-level XO method for molecular (ABC) magnetic property calculation. Subsystems (AB, BC, B) use high- (blue) / low-level (grey) methods, ABC uses low-level; XO combines their results to approximate ABC's high-level result.

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Waste Plastic-derived 3D Porous Photothermal Interfacial Evaporator for Synergistic Enrichment of Photothermal Efficiency and Lithium-Ion Kinetics

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Abstract

The rapid advancement of industrialization and the continuous growth of society are driving the demand for lithium, a crucial resource for enabling a sustainable energy future [1]. Lithium-ion sieves with high selectivity and excellent chemical stability are ideal candidates for extracting lithium from seawater. The photothermal evaporation technology combined with lithium-ion sieves has emerged as an efficient method for extracting lithium from seawater [2-3]. However, optimizing evaporation structures, thermal management, and lithium-ion adsorption kinetics are still significant challenges. Besides, plastic waste is rapidly increasing, creating substantial environmental challenges [4]. In the present work, waste plastics have been transformed into porous functional monoliths for photothermal interfacial evaporation. The porous monoliths were created using the thermally induced phase separation (TIPS) technique and were subsequently modified with polypyrrole@ multiwalled carbon nanotubes (PPy@MWCNT) and polyamide@ lithium titanate (PA@LTO). The PPy@MWCNT layer exhibits photothermal conversion, while the PA@LTO layer demonstrates the ability to absorb Li+ ions from brine water. The optimized monolithic evaporator shows a high evaporation rate and a significant Li+ adsorption capacity when exposed to solar radiation. Additionally, it demonstrates good cyclic stability and salt resistance. This study provides an easy and eco-friendly method for converting waste plastic into a scalable and eco-efficient solution for sustainable lithium recovery and fresh-water collection.

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Visible-Light-Driven Degradation of Bisphenol A in Recirculating Water Using Monolithic $BiVO_4$ Photocatalytic Foam Ceramics

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Zhanchong Zhao, Hosoda Kazuo, Yuying Mao and Masuda Hideki

Abstract

Bisphenol A (BPA), an endocrine-disrupting micropollutant in water, threatens ecology and human health, demanding efficient treatment. Visible-light photocatalysis is green but limited by slurry catalyst separation issues and low immobilized mass transfer efficiency. Herein, monolithic $BiVO_4$ photocatalytic foam ceramics with 3D interconnected pores were firstly fabricated via polymer sponge replication method. XRD, SEM, micro-CT, and UV-Vis DRS confirmed their pure crystalline phase, high porosity, and strong visible-light absorption—key for photocatalysis. Their BPA degradation performance was tested in a recirculating reactor under visible light, with optimized flow rate, catalyst length, and initial BPA concentration. The foams outperformed $BiVO_4$ powder slurries and plate-shaped catalysts, due to hierarchical pores enhancing light harvesting, mass transfer, and active sites. They also showed excellent stability/reusability, retaining high efficiency after cycles with negligible Bi^{3+} leaching, and superior energy efficiency. This work provides a scalable strategy for micropollutant removal, addressing conventional photocatalysis bottlenecks.

Keywords: Monolithic $BiVO_4$ foam ceramics; Visible-light photocatalysis; BPA degradation; Recirculating reactor; Porous structure

Sunday, November 30, 2025

1st Venue

Invited Lecture

Electrochemical Photolysis of Triazine Herbicides in Agricultural Water Using a $Fe_3O_4/SiO_2/TiO_2$ Photocatalyst

Institute of Photochemistry and Photofunctional Materials, University of Shanghai for Science and Technology

Yoshiaki Nomura, Manabu Kiguchi, Zhongoing Liang, Mei Ma, Akira Fujishima, Nobuhiro Hanada

Triazine herbicides such as simetryn and prometryn are widely used in agriculture but pose serious risks to non-target crops and water ecosystems due to their chemical persistence and phytotoxicity. This study presents a novel approach for the degradation of these herbicides using a magnetic $Fe_3O_4/SiO_2/TiO_2$ photocatalyst synthesized via a scalable coprecipitation method. Under 365 nm UV irradiation, both herbicides were completely decomposed within 240 minutes. A hydroponic bioassay using pak choi (Brassica rapa subsp. chinensis), a crop highly sensitive to triazines, confirmed the elimination of phytotoxicity after treatment. Interestingly, prometryn exhibited transient toxicity during early degradation stages, likely due to intermediate byproducts, whereas simetryn showed a smoother detoxification profile. The magnetic properties of the photocatalyst enabled efficient recovery, making it suitable for large-scale agricultural water treatment. This integrated protocol combining chemical analysis and plant-based toxicity screening offers a practical and ecologically sound method for evaluating water safety in agricultural environments.

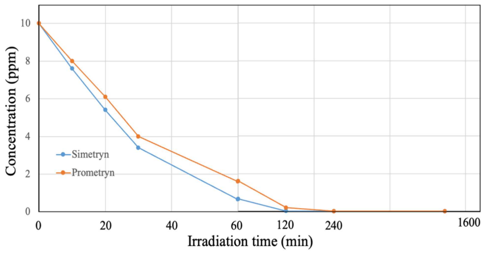

Figure: Survival rate of pak choi after photocatalytic treatment of 10 ppm simetryn and prometryn solutions. Complete detoxification was achieved after 4 hours of UV irradiation using $Fe_3O_4/SiO_2/TiO_2$ photocatalyst.

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Highly efficient sunlight-driven CO_2 hydrogenation to methanol over Ni-based intermetallic catalysts under atmospheric pressure

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Yanhong Luo, Linjia Han, Tianxing Liu, Xianhua Bai, Qingbo Meng

Utilizing solar energy to convert CO_2 and green H_2 into solar methanol under atmospheric pressure is an attractive approach for achieving both carbon neutrality and solar energy storage[1]. Recently reported photothermal technology for methanol production through catalyzing CO_2 hydrogenation shows promising prospect to storage solar energy into liquid fuel. However, in the works with high photothermal catalytic performance, rare metals such as Ruthenium and Indium are mostly used, limiting the large-scale application of photothermal methanol production[2]. Moreover, current photothermal catalytic CO_2 hydrogenation requires an external electric heating source to generate high temperatures (>200°C) and intense sunlight irradiation (light intensity ~10 kW m^{-2} = 10 suns) to produce hot carriers, making the direct use of natural sunlight inconvenient. Therefore, it is an urgent to develop cost-effective and highly active catalysts to achieve efficient CO_2 photothermal hydrogenation to methanol at ambient pressure and under natural sunlight (≤1 sun) without additional energy input.

Here, we design a series Ni-based intermetallic catalysts to effectively catalyze the hydrogenation of CO_2 to solar methanol at ambient pressure[3]. Under atmospheric pressure and natural sunlight irradiation (≤1 sun) without external electric heating, Ni-based intermetallic catalyst achieved a high generation rate of 674 μmol g^{-1} h^{-1} for methanol production with 100% selectivity. This rate sets the highest record for the natural solar-driven CO_2 hydrogenation to methanol in continuous-flow reactors under atmospheric pressure. Additionally, the catalyst can be synthesized through the traditional co-precipitation method, demonstrating its potential for future large-scale application.

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Janus adhesive hydrogel scaffold for monitoring pressure and shape changes in human intestinal sphincter

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Intestinal sphincter dysfunction poses significant challenges in clinical treatment, necessitating the development of advanced biomaterials for effective repair and regeneration. Conventional hydrogel scaffolds, while biocompatible and structurally similar to natural tissues, often suffer from poor mechanical robustness, limited adhesion, and a lack of intelligent responsiveness, hindering their efficacy in dynamic and high-pressure environments. To overcome these limitations, we present a Janus adhesive hydrogel scaffold with biomimetic design and sensing capabilities. The porous inverse opal structure enhances mechanical stability and tissue interaction, and a multi-channel sensing system enables real-time detection of shape and pressure changes. Coupled with artificial intelligence (AI)-driven modeling, the scaffold can identify abnormal pressure patterns.

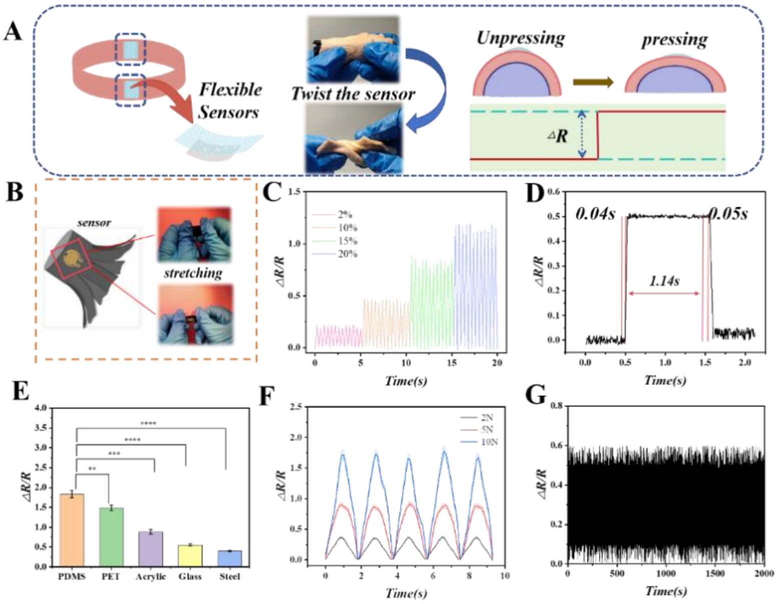

Figure. Performance testing of flexible pressure-sensitive sensors.

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Slow Photoindud Electron Relaxations of Semconductors: Equipments and Softwares

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Baoshun liu

Abstract：

Relaxation is the spontaneous process of matters from thermodynamic non-equilibrium state to equilibrium states; this universally exists in nature. Under light illuminations, the valence electrons of semiconductors were promoted to conduction band (CB), and the semiconductors are thus transferred to nonequilibrium state. The relaxations of nonequilibrium semiconductors correspond to the relaxation of the photoinduced electrons from CB to the valence band (VB). The photoinduced electron could occur through different pathways, which can cause different physical and chemical effects. Directing the photoinduced relaxation through desired pathways could realize the hoped effects, such as photoluminescence, photovoltaics, and photocatalysis, so it is meaningful to study the photoinduced relaxations. In recent years, our group is focusing on the equipment, measurements, and analysis of the slow relaxations from microseconds to hours. Furthermore, a software basing on the Monte-carlo model, quasi-equilibrium model, Markov Chain model, and inversion analysis model are also under developing to resolute the relaxation kinetics.

Photoacoustic Spectroscopy for Electrochemical Interface Analysis: Advances and Applications

Material and Environmental Chemistry Course, Department of Fundamental Engineering, School of Engineering, Utsunomiya University(The Electrochemical Society of Japan (ECSJ) Fellow)
Sachio Yoshihara

Photoacoustic spectroscopy (PAS) has emerged as a powerful tool for probing electrochemical interfaces, complementing techniques such as scanning tunneling microscopy (STM) and quartz crystal microbalance (QCM). First observed by Alexander Graham Bell in the 1880s as the optoacoustic effect, PAS exploits the conversion of modulated light into acoustic signals, enabling sensitive analysis of light absorption in solids. With the advent of lasers, PAS has been revitalized and applied to evaluate electrochemical reactions at electrode/solution interfaces.

This report reviews recent advances in the application of PAS to electrochemistry. Key applications include monitoring electrodeposition and electroless deposition processes, extending to atomic-level underpotential deposition (UPD), and determining quantum efficiencies of photoelectrochemical reactions on semiconductor electrodes. PAS has also been applied to track phase transitions in emulsions and to study ink absorption in paper substrates.

Recent developments by Prof. Bunsho Ohtani introduce a method for identifying metal-oxide powders using the energy-resolved distribution of electron traps and conduction-band bottom positions as structural fingerprints. This approach, based on sample-pair coincidence measured with reversed double-beam PAS (RDB-PAS), highlights the method’s capability to probe both surface and bulk properties with high specificity.

Overall, PAS provides a versatile, non-invasive approach for investigating electrochemical processes, offering new insights into interfacial reactions and material characterization. Its expanding applications suggest significant potential for advancing both fundamental studies and practical electrochemical technologies.

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Solution Plasma Driven Production of Hydrogen Peroxide

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Solution plasma catalysis is an emerging electricity powered technology, [1-4] which is promising for the production of high concentrations of H_2O_2 from pure water and oxygen. The plasma formed by the discharge can effectively activate H_2O and O_2, converting them into chemically active substances such as hydroxyl radicals (·OH), superoxide radicals ($\cdot O_2^-$), and singlet oxygen ($^1O_2$), where the recombination of ·OH is the main reaction process for the formation of H_2O_2 at high rates. However, the susceptibility of ·OH to uncontrolled reactions with other reactive radicals reduce the selectivity for solution plasma synthesis of H_2O_2. To this end, we propose the strategy of combining a highly reactive plasma with a highly selective catalyst to address the uncontrollable reaction of radicals in order to increase the yield of H_2O_2. In this talk, I would like to focus on the integration of solid catalysts into solution plasma channels with the objective of modulating reactive radical reaction pathways, for example, modified C_3N_4, and utilizes machine learning and theoretical calculations to carry out a series of catalyst screenings and synthesizes solution plasma catalyst for the conversion of pure water and oxygen to high concentrations of H_2O_2.

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Oriented Assembly of Mesoporous Catalytic Materials Based on Single-Micelle Building Blocks

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Linlin Duan, Ying Wan

The transformation from traditional trial-and-error methods to precise design and construction of catalytic active sites remains a critical challenge in developing novel catalytic materials. While single-micelle-directed synthesis of functional mesoporous materials has attracted significant attention[1], the targeted design of mesoporous catalysts with multifunctional integration for practical applications still poses substantial challenges. We developed a thiol-functionalized single-micelle interfacial assembly strategy to construct fully exposed single-atom-layer Pt clusters (~1.2 nm) on 2D mesoporous TiO_2 nanosheets, achieving efficient hydrogenation of 4-nitrostyrene under mild conditions (TOF up to 2424 h^{-1}) with 100% selectivity for 4-aminostyrene[2]. To address the challenge of hierarchical pore construction, we designed zeolite@mesoporous silica core-shell nanospheres via a dynamic micelle assembly strategy, achieving 75% yield in palmitic acid esterification. The hierarchical gradient pores facilitated rapid mass transport and water removal, shifting reaction equilibrium[3]. By modulating Pd *d*-electron density based on heterocycle adsorption principles, we achieved >99.9% selectivity in 2-phenylpyridine hydrogenation to 2-phenylpiperidine. The catalyst maintained excellent stability over 8 batch cycles and 800 h continuous flow operation with negligible metal leaching[4].

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Vascularized brain organoids with 3D-printed artificial vessels

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Haibo Ding, Zhongze Gu

Brain organoids are widely used to model brain development and diseases. However, a significant challenge in their application is the insufficient supply of oxygen and nutrients to the core region, restricting the size and maturation of the organoids. In this study, two-photon polymerization 3D printing was employed to fabricate high-resolution meshed vessels to vascularize brain organoids and enhance the nutritional supply to their core areas. The vascularized organoids exhibit dimensional breaking growth and enhanced proliferation, reduced hypoxia, and apoptosis, suggesting that the 3D-printed vessels partially mimic vascular function to promote the culture of organoids. Furthermore, cortical, striatal, and medial ganglionic eminence (MGE) organoids were differentiated to generate cortico-striatal-MGE assembloids by 3D-printed vessels. The enhanced migration, projection, and excitatory signaling transduction were observed between different brain regional organoids in the assembloids. This study presents an approach using direct laser writing to construct vascularized brain organoids and assembloids, enhancing development and assembly, and offering a research model and platform for neurological diseases.

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In vivo Drug Monitoring Using Boron-Doped Diamond Microelectrodes.

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Genki Ogata, Yasuaki Einaga

Real-time detection of the local effects of administered drugs *in vivo* is crucial for developing effective medical therapies. However, conventional methods often require large sample volumes and offer limited temporal resolution. In this study, we propose an electrochemical approach using boron-doped diamond (BDD) electrodes to monitor temporal changes in local drug concentrations. BDD possesses excellent electrochemical characteristics and biocompatibility, making it an ideal sensing material for *in vivo* drug measurement. We developed a needle-type BDD microsensor with a tip diameter of ~40 μm, capable of detecting changes in drug concentrations with a time resolution of ~5 seconds [1]. This sensor can be integrated with conventional sensors. By using glass microelectrodes concurrently, we can also monitor cellular electrophysiological responses. We first evaluated bumetanide, a blocker of the Na^+,K^+,$2Cl^-$-cotransporter, a diuretic known to induce deafness potentially. In the cochlea of guinea pigs, we simultaneously measured changes in bumetanide concentration and extracellular potentials associated with hearing in real time. We next examined the antiepileptic drug lamotrigine, which inhibits sodium channels in the rat brain, and monitored its pharmacokinetics along with local field potentials reflecting neuronal activity. The effects of the anticancer drug doxorubicin were also investigated *in vivo*.

Furthermore, by incorporating a pressure transducer instead of glass microelectrodes, we monitored intraocular pressure changes to explore the relationship between antiglaucoma drugs—such as brimonidine tartrate and timolol maleate—detected by the BDD microsensors and their physiological effects [2, 3]. Additionally, we developed a prototype implantable system that enables the monitoring of drug kinetics in freely moving animals. This technology can be applied to a wide range of drugs in vivo and holds great potential to advance research in physiology, pharmacology, and the development of effective medical therapies.

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Sunday, November 30, 2025

2nd Venue

Invited Lecture

Bionic Gel-Derived Photothermal and Photocatalytic Materials

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Wenwei Lei

Hydrogels, soft materials consisting of abundant water within a 3D cross-linked polymer network, find broad applications in microfluidics, sensors, anti-fouling coatings, and tissue engineering. Many biological tissues are hydrogels, whose surface micro/nanostructures play vital roles in natural systems. Inspired by this, creating structured hydrogel surfaces has emerged as a promising approach for developing novel functional materials. Current fabrication techniques — such as surface modification, templating, lithography, and 3D printing — often face limitations in scalability and practicality due to complex processes and template specificity. Hence, a simple and scalable method is urgently needed.

This study presents a general strategy for constructing micro-nano structured hydrogel surfaces directly within a polymer diffusion layer during gelation. The process exploits the interface between two miscible polymers, combining polymer diffusion with cryo-induced gelation and microphase separation. Diffusion drives initial mixing, followed by freezing to induce gelation and structural formation. By adjusting gelation temperature and diffusion conditions, gradient or patterned surface architectures can be controlled. The resulting micro-nano composite hydrogel surfaces form an open capillary system capable of spontaneous anti-gravity liquid transport, suggesting promise in anti-dehydration, photothermal evaporation, and water treatment. Furthermore, incorporating $TiCl_4$ enables regulation of gelation and formation of TiO_2 with tailored crystallinity, yielding excellent photocatalytic performance for hydrogen evolution and pollutant degradation.

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Highly-Stable PbS Quantum Dot Inks Enables High-Efficiency Photovoltaics

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Yinglin Wang*, Xintong Zhang*, Yichun Liu

PbS quantum dots (QDs) have received significant attention in optoelectronic device, particularly the near-infrared photovoltaic, due to their size-tunable optoelectronic properties, solution processability, broad light-harvesting ability spanning from ultraviolen to infrared range. To enable the deployment of high-efficiency solar cells in scalable, flexible, and portable optoelectronic devices, it is essential to develop PbS QD inks that exhibit low surface-defects and high colloidal stability. Hence, we systematically optimized the synthesis and surface chemistry of PbS QDs to produce high-performance inks. We replaced the conventionally-used PbO precursor with an organic lead precursor, lead(II) acetylacetonate, to avoid the adverse effects of water by-products[1]. This method optimized the surface ligand composition of PbS QDs by reducing the hydroxyl ligands and increasing the OA ligands. And we proposed a ligand-solvent hydrogen-bonding strategy to improve the colloidal stability of PbS QDs, enabling the one-step solution-deposition of p-doped PbS QD with low surface defects[2]. With these high-quality QD inks, we achieved record-high efficiency (11.5%) in a novel solar cell architecture based on all-quantum-dot junction[3].

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Nanomaterials and Their Applications in Catalysts and Sensors

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Jin Luo

Nanostructured materials have diverse and expanding applications. This presentation will focus on their development and use in photoelectrochemical dye degradation, catalysis, and sensing technologies.

Various nanomaterials have been explored for the photoelectrochemical degradation of dyes. By engineering nanoparticulate film electrodes, dye decomposition rates have significantly improved. This enhancement is primarily due to reduced electron–hole recombination losses, allowing for more efficient and faster degradation processes.

In the field of catalysis, particularly for fuel cells used in electric vehicles, portable electronics, and advanced propulsion systems, nano-engineered alloy catalysts have shown great promise. These materials offer a cost-effective and robust solution, enhancing both the activity and stability of catalysts in polymer electrolyte membrane fuel cells and direct methanol fuel cells, thereby supporting the path toward commercial viability.

Additionally, there is a growing demand for portable and remote sensors capable of detecting volatile organic compounds and other hazardous gases in complex environments. Functionalized nanoparticles have been successfully developed for use in compact sensor array systems designed to monitor air pollutants effectively.

Rotaxane Dendrimers

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Hai-Bo Yang

Rotaxane dendrimers, an integrated combination of rotaxane and dendrimers, result in not only attractive topological structures but also potentially different and unexpected properties. During past few years, on the basis of our ongoing research interests in supramolecular self-assembly and organometallic chemistry, we initiated research on rotaxane dendrimers, in particular the ones with rotaxane branches. By the rational design and synthesis of organometallic rotaxane units as key building blocks, the synthetic challenge of the precise synthesis of a variety of high-generation rotaxane-branched dendrimers has been addressed[1]. Furthermore, we have successfully applied the resultant rotaxane dendrimers to diverse fields, including stimulus-responsive materials[2][3], photocatalysis[4], smart polymeric materials[5], soft robotics[6], and chiral luminescent materials[7], etc.

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Structural modulation of layered oxide cathode materials for high-performance sodium-ion batteries

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Sodium-ion batteries (SIBs) have emerged as an appealing alternative for large-scale energy storage, owing to their low raw material costs and environmental friendliness. The key to their practical application lies in finding appropriate cathode materials that can offer high energy density, rapid electrochemical response, and long cycle life. Sodium-based layered transition metal oxide cathodes (NTMOs) stand out among candidates, with high theoretical capacity and an energy-storage mechanism comparable to that of lithium-ion battery (LIB) cathodes. However, NTMOs encounter challenges during charge-discharge, including complex phase transitions, particle cracking, lattice oxygen loss at high potentials, and instability in humid environments, impeding their practical use.[1]

To address these issues, our team has made significant progress. We have prepared high-performance NTMOs through techniques such as optimizing preparation, morphology control, ion doping, and interface regulation, and put forward material kinetics and structure-stabilization mechanisms. For example, doping with Ta^{5+} and Sb^{5+} enhances the electrochemical performance by increasing the proportion of low-oxidation-state elements and improving structural stability and Na^+ diffusion.[2,3] The "atomic knife" technology, involving La^{3+} introduction, creates nanoscale NTMOs, improving sodium-ion diffusion and forming a protective heterogeneous phase.[4] Moreover, using K^+ in a wet-chemical method achieves dual modification, expanding the sodium-layer lattice and suppressing grain cracking.[5] Overall, our research on NTMOs modification aims to inspire the design of high-performance SIBs for wider applications.

Keywords: sodium-ion batteries; layered oxide cathode materials; structural design; ssodium storage mechanism

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Light-controlled ion translocation in conducting polymer membrane

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The selective uphill and downhill movement of protons in and out of photosynthetic membrane enabled by ion pumps and ion channels is key to the energy conversion in photosynthesis. Reproducing the functions of photosynthetic membranes in artificial systems has been a persistent goal. Here, we talk about the fabrication of artificial ion channels and ion pump using electropolymerized conducting polymer membranes. The ion translocation through the membranes can be controlled by the redox reactions of conducting polymer under an electrochemical potential [1, 2]. A visible irradiation induces a built-in electric field across the conducting polymer membrane due to its intrinsic photoelectronic property, which drives the cationic transport against the concentration gradient, demonstrating an ion-pumping effect [3]. We also apply the conducting polymer nanofluidic membrane for electrically regulated osmotic energy harvesting [4].

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Boron-doped diamond powder for functional electrode material

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Takeshi Kondo

Boron-doped diamond (BDD) electrodes or diamond electrodes are known to be useful for a durable electrode for electrolytic processes. As a result of electrolysis of sulfuric acid at diamond electrode, reactive oxidizing species, such as peroxodisulfate, can be generated at a high current efficiency. Such electrolyzed sulfuric acid exhibits strong oxidizing power, and is used for mineralization of organic compounds. In this study, we have developed a new method to fabricate a large-sized diamond electrode that can be used for electrolyzed sulfuric acid production by forming a BDD powder (BDDP)/silica composite film via spray coating (spray-coated diamond electrode).

BDDP was prepared by deposition of a BDD layer on the surface of diamond powder with a particle size of 3-6 μm via microwave plasma-assisted CVD [1]. Spray-coated diamond electrode was fabricated by coating BDDP/silica sol solution on a hydrophilic titanium substrate with a spray coater, followed by baking (Fig. 1).

10 mL of 50% sulfuric acid was electrolyzed at a constant current density of 20 mA cm^{-2} for 90 min at a spray-coated diamond electrode (electrode area: 0.5 cm^2). During the electrolysis, the electrode potential was stable around +3 V vs. Ag/AgCl, indicating that no deterioration of the electrode occurred even at highly positive potentials in sulfuric acid. Generation of reactive oxidizing species was confirmed by a titration method. The results indicate that the spray-coated diamond electrode can be used for electrolyzed sulfuric acid production. A large-sized spray-coated diamond electrode was also prepared in the same way using a 20×20 cm^2-sized titanium substrate. Therefore, the spray coating method is expected to be useful for scaling up of a diamond electrode for sulfuric acid electrolysis.

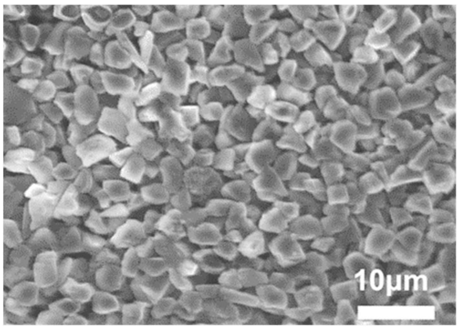

Fig. 1 SEM image of spray-coated diamond electrode surface.

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Manipulation of active site for photocatalytic CO_2 reduction to value-added chemicals

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Solar-driven selective reduction of CO_2 to value-added chemical is bottlenecked by the competitive reaction (hydrogen evolution reaction) and C–C coupling. This talk presents two strategies for promoting the selectivity of target products. (1) By employing CdS and cobalt bipyridine as a model, we engineered the surface of CdS to create an electric field at the inorganic–organic interface, allowing high-throughput electron transfer to suppress H_2 evolution, thereby enhancing CO_2 reduction. Through in situ and transient spectroscopy techniques, we discovered that CdS functionalized with -COOH groups demonstrates remarkable noncovalent interactions and improved charge transfer capabilities compared to those functionalized with $-NH_2$ groups; (2) constructing a chlorine (Cl)-bridged Ti-Ag dual-site catalysts for boosting the selectivity of C_2H_4 product. The introduction of Cl on Ti-Ag dual sites spatially separates C–C coupling and intermediate protonation, making *CO dimerization thermodynamically more favorable than *CO hydrogenation.

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Sunday, November 30, 2025

Main Venue

Academician Speech

Invited Lecture

Quantum ionics: ultra-low energy consumption of energy conversion/information transmission in biological system

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Abstract

Life system presents an ultralow energy consumption in high-efficiency energy conversion, information transmission and bio-synthesis. The total energy intake of human body is about 2000 kcal/day to maintain all our activities, which is comparable to a power of ~ 100 W. The energy required for brain to work is equivalent to ~ 20 W, while the rest energy (~ 80 W) is used for other activities. All in vivo bio-syntheses take place only at body temperature, which is much lower than that of in vitro reactions. To achieve these ultralow energy-consumption processes, there should be a kind of ultralow-resistivity matter transport in nanochannels (e.g., ionic, molecular channels), in which the directional collective motion of ions or molecules is a necessary condition, rather than the traditional Newton diffusion. Directional collective motion of ions and molecules are considered as ionic/molecular superfluid. The research of ionic/molecular superfluid will promote the development of neuroscience and brain science, develop quantum ionic technology, and produce a series of disruptive technologies.

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Dual-band Tunable Electrochromic Window for Climate-Responsive Buildings

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Palin Ngaotrakanwiwat [a,b,*] , Anan Junsukhon [b], Tetsu Tatsuma [c]

The protection against heat gain and heat loss from sunlight through windows in glass buildings, located in various climates around the world, is a promising approach to significantly reducing electricity demand for heating, ventilation, and air conditioning (HVAC), thereby improving the thermal comfort of residents and contributing to a more sustainable future. The dual-band electrochromic window can be controlled by residents to independently adjust the transmission of visible light and near-infrared (NIR) radiation in response to changing climatic conditions. The cool and dark operating modes are suitable for hot climates due to their reduction of NIR transmission, whereas the warm and bright modes are preferred for cold climates, as they allow NIR transmission. The electrochromic window consists of an architecturally arranged structure of transparent conductive glass/electrochromic layer/ion transport layer/ion-conductive layer/transparent conductive glass. In this work, the suitable selection of cathodic–anodic electrochromic materials for the electrochromic layer enabled manipulation of visible light and NIR transmission through plasmonic and polaronic effects. The cool mode maintained visible light transmission (500 nm) at 85% while reducing NIR transmission (1000 nm) at 27%. Further reductions in transmission were observed in the dark mode, reaching 0.6% and 0.04% for visible and NIR light, respectively. Conversely, the bright mode allowed transmissions of 88% and 82%, respectively, while the warm mode reduced visible light to 47% and retained NIR transmission at 75%. Therefore, the dual-band electrochromic window is an innovative solution that simultaneously improves energy efficiency in glass buildings and reduces CO_2 emissions from electricity generation.

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Design and Preparation of Photoinitiators Based on Coumarin-Carbazole Fused Conjugated Structure

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Xinyue Guo, **Mingjin***

As key components of photopolymerization systems, photoinitiators (PIs) absorb the energy from light sources, generating active species to initiate the polymerization reaction. With the growing requirements on environmental protection and energy conservation, photocuring technology using light-emitting diode (LEDs) has gradually become mainstream. At the same time, the rise of emerging light sources, such as visible light LEDs and near-infrared lasers, has raised higher demands for the absorption range of PIs. However, commercial PIs still have limitations in terms of absorption wavelengths, migration stability, and yellowing. Furthermore, the demand for PIs with sensitivity to longer wavelengths in the field of two-photon polymerization (TPP) is increasing. Such PIs need to exhibit a large two-photon absorption (TPA) cross-section, high photosensitivity, and stability.

In this report, carbazole and coumarin, two chromophores with excellent optoelectronic properties, were used as the core molecular building blocks in the molecular engineering of PIs. Based on regulating substituents, expanding the molecular conjugated backbones, and introducing functional groups, three series of photoinitiator systems combining carbazole and coumarin groups have been designed and synthesized. And their photophysical properties, photochemical reaction mechanisms, and light-induced polymerization performance were studied. Through systematic structure-activity relationship analysis, the molecular structure design is gradually optimized to develop one/two-photon PIs that can be applied under LED light sources and near-infrared lasers.

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From Precision Chemistry to Orbital Catalysis

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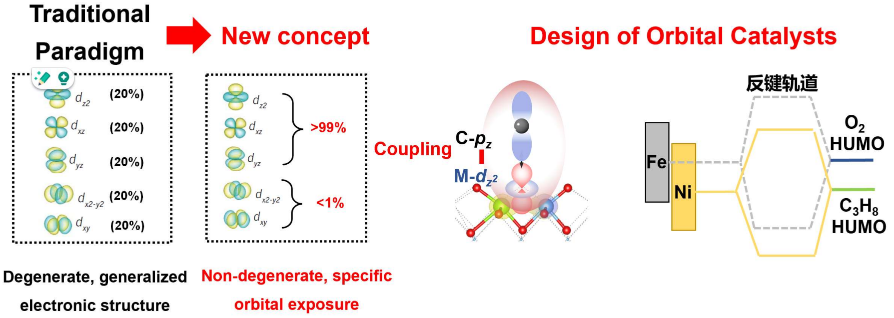

To address the urgent demand for high-selectivity chemical synthesis, “precision chemistry” has emerged as a pivotal paradigm in modern chemical science. As early as the 2011 International Year of Chemistry, we advocated for chemistry’s transition toward precision—a vision underscored by Nobel Laureate Ben L. Feringa’s forward-looking insights. Today, China’s chemical industry faces the critical challenge of overcoming its "large but not strong, diverse but not refined" development bottleneck. With a fine-chemical rate of ~45% (significantly lagging behind developed nations’ >70%), constructing a theoretical framework for precision chemistry is imperative. This report focuses on catalysis—the cornerstone of chemical engineering—and introduces “orbital catalysis”, a groundbreaking concept[1−4] that transcends the traditional focus on geometric configurations of active sites. By targeting electronic orbital-level modulation, we establish a new paradigm for catalytic science. Key innovations include: Orbital-Specific Regulation Precise manipulation of *d*-orbital interactions (e.g., d_{z^2} occupancy) to control reaction pathways, dynamic Spin Engineering and Industrial Validation. Orbital catalysis merges theoretical depth with practical impact, offering a roadmap for sustainable chemical manufacturing and positioning China at the forefront of catalytic innovation.

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Photocatalytic Dry Reforming of Methane for Syngas Production

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Dry reforming of methane (DRM) is an attractive reaction, which converts greenhouse gasses into valuable syngas ($CH_4 + CO_2 \rightarrow 2CO + 2H_2$, $\Delta H_{298K} = +247$ kJ mol^{-1}). However, it requires high temperature to proceed. The present study reports the efficient DRM reaction under extra low temperature using the rhodium-loaded strontium titanate ($Rh/SrTiO_3$) photocatalyst. As shown in Fig. 1, the catalyst drove the DRM reaction over 50 % H_2 production yield under ultraviolet (UV) irradiation even at low-temperature conditions.[1] Generated amounts of CO and H_2 were twice as those of CH_4 and CO_2 consumption, suggesting that the stoichiometric DRM reaction proceeds without causing any side reactions.

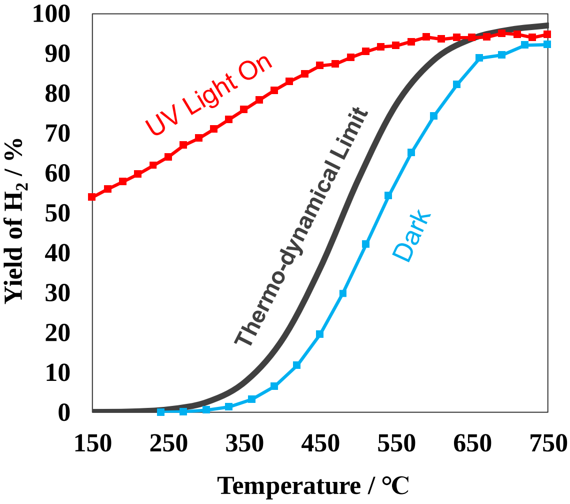

Fig. 1. DRM performance of our photocatalyst.

The results of the surface temperature,[2] the source DRM gas composition dependence,[3] and the action spectrum [1, 4] suggest that the present DRM reaction is driven by photogenerated charge carriers rather than by a photo-thermal process. Based on our isotope trace experiment [1] and the analytical study using a gas-phase photoelectrochemical cell,[5] the lattice oxygen ions (O^{2-}) play an important role in the DRM reaction under UV irradiation. Photocatalytic CH_4 oxidation and CO_2 reduction are linked by O^{2-} ions, which act as a mediator in redox reactions to produce H_2 and CO equally. By optimizing the conductivity of O^{2-} ions in metal oxides like CeO_2, we could greatly improve the photocatalytic DRM activity.[6]

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Composite formation with titanate nanotubes for hydrogen generation

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Photocatalyst materials which are suitably stable often have large band gaps, and can only be activated by UV light. Our research has involved the synthesis and modification of novel inorganic nanostructured materials coupled with organic semiconductors in order to exploit their properties in visible light active photocatalytic systems. In this talk I will present our recent progress in self-catalysed breakdown of titanate nanotubes by carbon nitride which can be viewed as a general method for improving catalysis synthesis and design, whilst simultaneously reducing the complexity and energy footprint of active catalyst synthesis. I will also present our preparation of a new phase with boron nitride by a novel mixed hydrothermal/solvothermal method at different temperatures and compared this to physical mixing. The composite prepared at 140 °C showed evidence of Ti-O-B bond formation and enhanced photocatalytic hydrogen production efficiency.

Biography of presenting author Dr. Graham Dawson joined XJTLU in March 2013. Before taking this position he worked at the Suzhou Institute of nanotechnology and Nanobionics (SINANO) as a postdoctoral research assistant then as an associate professor. During this time, Dr. Dawson was principal investigator of several provincial and national level projects. He completed his PhD studies under Professor Wuzong Zhou at the University of St. Andrews, Scotland

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Biosensing Application of SiO_2-TiO_2 Hybrid Inverse Opal Fabry-Pérot Layers

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Since the development of the sol-gel co-growth method by Joanna Aizenberg et al., inverse opal (IO) structured ordered porous materials have demonstrated significant potential in applications such as photonics, sensing, and catalysis. Their systematic researches have revealed the controllable migration characteristics of the photonic band gap in this type of material, offering a valuable reference for the design of functionalized IO structures. In fact, the Fabry-Pérot fringes can serve as an independent optical tracking signal source that is independent of the photonic bandgap due to their sensitivity to RI changes. Building upon this advantage, we developed an ordered porous layer interferometry (OPLI) system. This system enables high-precision, label-free, real-time monitoring of biomolecular interactions, including enzyme-substrate hydrolysis, fibrinolysis and biological molecule detection, etc. by detecting Fabry-Pérot fringes shifts in opal-structured films.

In this work, we fabricated uniformly ordered SiO_2-TiO_2 hybrid inverse opal Fabry-Pérot layers based on sol-gel co-growth strategy and utilized their unique Fabry-Pérot fringes for real-time and dynamic monitoring of lipid degradation processes. The biosensor demonstrates excellent sensitivity and a wide linear range for real-time process monitoring, offering new possibilities for studying liquid-phase biomolecular interactions. This integrated platform shows significant potential for applications in clinical diagnostics and pharmaceutical research.

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Green conversion of biomass derived compounds to value-added chemicals

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The utilization of renewable biomass resources is an essential strategy to reduce dependence on fossil fuels and to build a sustainable society. Conventional processes for producing fuels and chemicals often require high temperatures and pressures, which impose environmental burdens. In contrast, photocatalytic and electrochemical reactions operate under mild conditions, offering green and sustainable alternatives. In this study, biomass-derived saccharides were employed as starting materials, and their conversion into a wide range of value-added products was examined.

Photocatalytic oxidation of glucose yielded organic peroxide solutions with strong antimicrobial activity. Remarkably, these solutions were effective not only against *E. coli* but also against spore-forming bacteria, which are resistant to conventional disinfectants. This demonstrates the potential of biomass-derived disinfectants for food safety and medical applications. In another approach, glucose was converted into methane gas using metal-loaded titanium dioxide photocatalysts. This process provides a sustainable route to obtain methane, an important fuel and industrial feedstock, directly from renewable resources under ambient conditions, suggesting future applications in solar-driven energy systems. Photocatalytic transformations also enabled the synthesis of rare sugars and related compounds. Glucose was converted into various rare monosaccharides, fructose into lactones, and maltose into rare disaccharides. Importantly, these reactions proceeded in a stereochemistry-preserving manner, producing D- or L-forms consistent with the starting materials. Rare sugars are of high interest due to their biological activities and potential uses in food and pharmaceuticals, while lactones and disaccharides offer new opportunities in materials and biomedical research. To complement these findings, electrochemical oxidation using boron-doped diamond electrodes was applied to glucose. This method efficiently produced rare sugars and offers excellent controllability and scalability, highlighting its potential for mass production and industrial application.

These results demonstrate that glucose can be converted into disinfectants, fuels, and functional sugars through green processes. By combining photocatalytic and electrochemical reactions, we provide versatile strategies for biomass valorization, bridging fundamental research with practical applications.

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Advanced photocatalytic technology: Electrically assisting gasphase reaction and triphase H_2O_2 synthesis

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Semiconductor doping is an effective strategy for improving the light absorption efficiency and the photogenerated carrier transport in photocatalysts. However, bulk defects induced by doping act as recombination centers, accelerating the recombination of carriers, which is detrimental to the photocatalytic performance. To address the issue, a novel electric-assisted photocatalytic technique was developed to reduce the recombination of the carriers trapped by the defects. The technique involves applying a low external voltage to a self-doped TiO_2 nanotube film, without any electrolyte and counter electrode. The remarkable improvement in the charge carrier dynamics under the electric assistance is attributed to the significant promotion of photogenerated electron fluxes and prevention of charge recombination. The electric-assisted photocatalytic technique is compatible with a gas-phase reactive system, e.g., VOCs removal, H_2O_2 synthesis, and CO_2 photoreduction. The technique is sufficiently advanced to allow scale-up of the photocatalytic process from laboratory scale to industrial-scale.

The coupling of H_2O and O_2 by solar energy is regarded as the Holy Grail reaction for a manufacturing route of H_2O_2; however, its efficiency has suffered from low O_2 solubility in aqueous solution and difficult-to-inhibit side reactions. To address the problem, a liquid–solid–gas triphase system has been designed to directly utilize abundant atmospheric O_2 for H_2O_2 photosynthesis.

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Photocatalytic CO_2 Reduction Based on Non-covalent Interfaces

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Photocatalysis has attracted significant attention due to its importance and potential applications in energy and environmental fields. However, traditional ohmic or Schottky contacts between supported cocatalysts and catalysts can hinder interfacial charge transfer, thereby suppressing photocatalytic performance. According to research reports, constructing non-covalent interfaces is a promising strategy to promote interfacial charge transfer and effectively suppress charge recombination. In this study, a pyrene-based light-absorbing centre with excellent light absorption properties was designed and synthesized. By employing a classic molecular catalyst as the catalytic center and leveraging non-covalent interactions such as π-π stacking, a spatial charge transport channel was constructed to regulate efficient spatial charge transfer pathways between the photocatalyst and cocatalyst during photocatalytic processes, thereby enhancing the overall photocatalytic activity. This approach provides a feasible new strategy for addressing the critical challenge of directional charge transfer in photocatalytic reactions, offering significant scientific value for exploring and designing high-efficiency systems

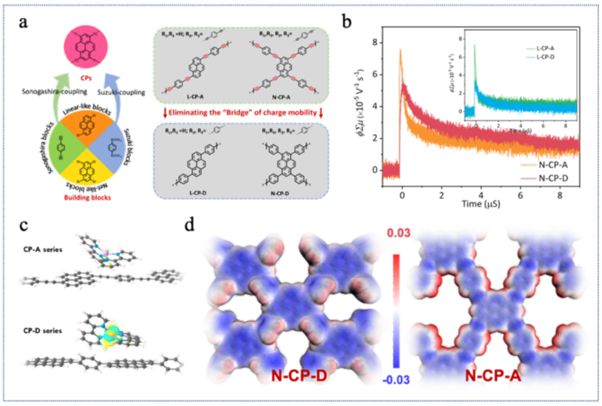

Figure1. Structure induced localization or delocalization of photoexcited electrons in CPs

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A Novel Artificial Photosynthetic System

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Using the principle of photosynthesis to convert CO_2 and water into various chemicals and fuels is an important strategy for achieving carbon neutrality and the sustainable development of human society. Over the past two decades, research in this field has progressed rapidly and garnered widespread global attention. However, many of the resulting systems still fail to accurately and authentically mimick the natural photosynthestic process[1,2].

Recently, we proposed a novel artificial photosynthetic system. The specific idea is to (1) spatially and temporally separate the two core photosynthesis reactions: water splitting and CO_2 reduction[3]. (2) Use solar energy to independently drive these two reactions, and (3) integrate these two reaction systems into a whole artificial photosynthetic system. This innovative approach offers four key benefits: (1) the ability to use proven technologies for water splitting and CO_2 hydrogenation, (2) the potential for easy system scaling, (3) the ability to independently optimize the two reactions, offering a range of choices in terms of efficiency, cost, and end products, and (4) the capability to enhance the CO_2 supply by avoiding gas transport in liquid electrolytes.

Using this new artificial photosynthetic system, we employed $CuOx/ZnO/Al_2O_3$ and Ag-single-atom supported NiO nanosheets as catalysts for CO_2 hydrogenation step, respectively. The solar-to-chemical energy conversion efficiency has highly improved to 15.5% for a 1.268 m^2 system and over 16% for a 103m^2 system[3,4]. This research lays the groundwork for designing practical, natural sunlight-driven artificial photosynthetic systems and highly efficient platinum-free CO_2 hydrogenation catalysts. It signifies a major step towards harnessing solar energy more efficiently and sustainably, and opens up thrilling possibilities for future research and development in this field[5,6].

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Artificial Intelligence for Materials Science: Transforming Research Paradigms

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Materials science has been facing the problems of high system complexity, low degree of data standardization, and long research chain, which also reveals the limitations of the traditional research paradigm. AI technology is good at handling high-dimensional and multi-scale data, and is able to discover the complex correlation between parameters, which provides a possible solution to the current dilemmas of materials science research.

In this report, we propose three paradigms for materials research and development: the foundation is a Deep Fusion of Data, Models, and Compute; the core methodology is a Symbiotic Drive of Data and Knowledge; and the ultimate goal is End-to-end Materials Development. We believe that AI can equip researchers with cross-disciplinary knowledge and thinking, unleash their innovative potential, and serve as an effective tool covering the entire process from fundamental research to productization in materials science. AI may be able to bring a new future for materials science research that is "without clear understanding" but fast-moving.

Poster Presentation

Surface/Interface Modification Enhances the Photoelectrochemical Water Splitting Performance of Oxide Photoanodes

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Photoelectrochemical (PEC) water splitting is a primary pathway for converting solar energy into clean hydrogen using semiconductors. The water oxidation reaction at the photoanode involves a four-electron process, which significantly influences the overall efficiency of water splitting. Therefore, enhancing the photoelectrochemical performance of photoanodes is crucial for achieving high-efficiency PEC water splitting.

Among photoanode materials, small-bandgap semiconductors such as hematite (Fe_2O_3) and bismuth vanadate ($BiVO_4$) are highly promising due to their suitable valence band positions. However, severe charge recombination of these photoanodes greatly limits the transport of photogenerated carriers. To address this issue, the research of the interface, bulk, and surface modifications were conducted: Well-crystalline exfoliated monolayer structures, porous conductive architectures, or nanocone arrays were modified on substrate to enhance the PEC performance; Methods such as high-temperature rapid annealing and laser annealing were developed to improve the effective substitutional doping of atoms; Surface modifications with cocatalysts such as FeOOH, CoOOH, Co-Pi, and Co-MOFs, as well as their derivatives, were employed to accelerate surface hole transfer, reduce overpotential, and promote the four-electron oxidation process, highly efficient photoelectrochemical photoanodes were achieved.

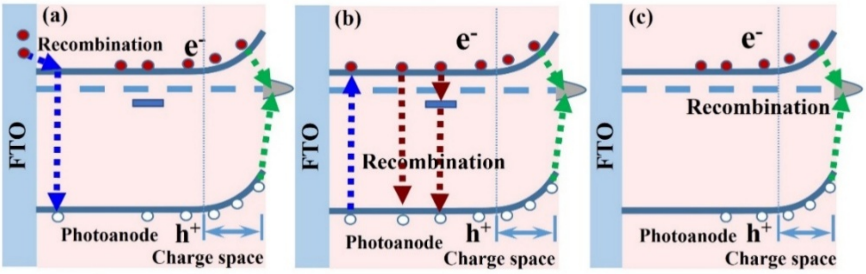

Fig. 1. Recombination process caused by the (a) reverse flow of carriers at the interface between the substrate and the light-absorbing material, (b) carriers inside the light-absorbing material, (c) recombination process at the photoanode surface.

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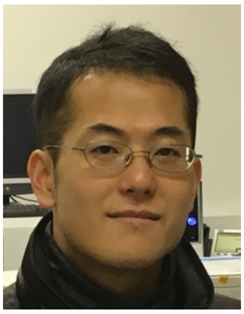
Metal Cation Doping into TiO_2 Photocatalysts via Liquid Phase Deposition for Decomposing Acetaldehyde



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Titanium dioxide (TiO_2) is a widely studied semiconductor photocatalyst that exhibits strong environmental purification capabilities under light irradiation. [1,2] Elemental doping of TiO_2 has been recognized as an effective strategy to enhance its photocatalytic performance. In this study, we successfully fabricated coating films of anatase-phase TiO_2 doped with various metals (Al, Ga, Fe, Co, Ni, Cu) on glass substrates via a low-temperature, atmospheric-pressure liquid-phase deposition method. Among the dopants, Fe, Ga, and Cu were incorporated at higher concentrations compared to Co, Ni, and Al, which can be attributed to differences in ionic radius and chemical stability. Doping also induced a narrowing of the optical band gap, extending light absorption into the visible region, with Fe-doped TiO_2 (4 at%) achieving a band gap of 2.4 eV. [3] Furthermore, the doped TiO_2 samples demonstrated photocatalytic activity for acetaldehyde degradation.

The degradation activity followed the order: Cu > Ni > Co > undoped > Ga > Al > Fe. Interestingly, higher band gap values correlated with increased acetaldehyde decomposition activity, whereas no correlation was observed with Raman peak (E_g mode) positions, indicating that lattice distortion does not significantly influence activity. Crystallinity was found to be important only above a certain threshold, beyond which further improvement had little effect. These results highlight that metal-ion doping via low-temperature synthesis is a promising approach to tailor electronic structure and surface properties, enabling enhanced photocatalytic performance for volatile organic compound degradation.

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Photo-induced Minor Enantiomer Stereoinversion

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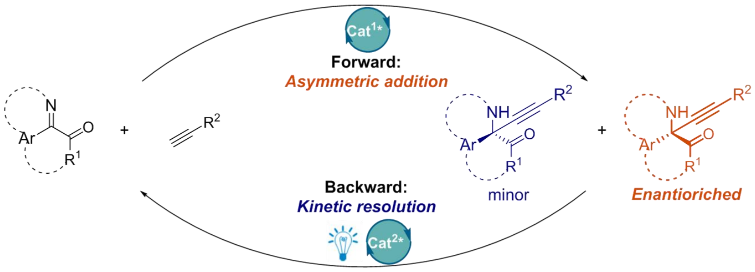
Main Text

The precise synthesis of target molecules with ultra-high enantioselectivities via asymmetric catalysis plays an important role in the development of medicine and materials. Over the past few decades, chemists have made numerous attempts to develop new asymmetric catalytic modes and design efficient chiral catalysts to achieve highly enantiopure target molecules. Generally, the enantioselectivity of traditional asymmetric catalytic modes is closely linked to chiral catalysts, with few modes affording ultra-high enantioselectivity[1-3].

Herein, we develop a minor enantiomer stereoinversion (MES), which integrates a forward asymmetric stereocenter-generation with a backward photo-induced kinetic resolution, enabling the stereoinversion of the minor enantiomeric products into the desired products. This mode can provide ultra-high enantioselectivity without significant dependence on the fine structure and optical purity of the catalyst. Applying a Zn/Cu-catalyzed MES system to reactions between ketimines and arylacetylenes efficiently synthesized chiral quaternary α-amino acid derivatives, all exhibiting >99% *ee*.



- Novel asymmetric catalytic paradigm
- Novel chiral amplification mode
- Products with infinitely close to 100% *ee*
- Appliable to deracemization with >99% *ee*

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Fabrication and Biosensing Application of SiO_2-TiO_2 Hybrid Inverse Opal Fabry-Pérot Layers

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Porous nanomaterials with optical interference effect have broad prospects in the application of biosensors. However, the controllable preparation and performance optimization of existing interference layers still face significant challenges. Most of the traditional interference layers prepared by electrochemical etching processes, such as porous silicon and anodic aluminum oxide, generally have problems including poor structural controllability and difficulty in large-scale production. Their closed pore structure further leads to restricted mass transfer, seriously affecting real-time detection of biomolecular interactions. Our team has found that the bottom-up approach of colloidal crystal self-assembly is an effective method for the preparation of ordered porous opal materials in response to these key issues. A novel label-free biosensing platform was developed by further using this method to prepare opal-structured nanomaterials for the analysis of biomolecular interactions.

It is worth noting that the interference substrate with the opal structure, due to its relatively low porosity (26%), to some extent limits its applications. we employed the sol-gel co-growth strategy to synthesize SiO_2-TiO_2 hybrid inverse opal Fabry-Pérot layers, replacing the existing opal-structured interference substrate and systematically investigated the interference effect of the Fabry-Pérot layers. Furthermore, we constructed an ordered porous layer interferometry system based on the lipid enzymatic hydrolysis reaction interference layer. By utilizing the interaction between white light and the interference layer, the change of Fabry-Pérot fringes was transformed into optical thickness change, thereby enabling real-time capture of the dynamic changes in lipid degradation/dissociation at the microscopic interface. This achievement not only provides a new paradigm for the controllable synthesis of inverse opal structured interference substrates but also combines the inverse opal structure with time-resolved interferometry technology, opening up a brand-new path for label-free biosensing.

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Interference effect of tubular colloidal crystal films and their biosensing applications

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Xiaoling Zheng, Weiping Qian

Several studies have focused on developing cylindrical colloidal crystal by self-assembling nano-microspheres within microcapillaries, which have primarily been applied as support materials for microreactors, catalysis and column chromatographies.[1]
Our group has developed an ordered porous layer interferometry (OPLI) system based on silica colloidal crystal (SCC) films, which enables real-time and dynamic monitoring of biochemical processes such as fibrinolysis, protein-ligand interactions, and lipolysis.[2]
In this study, structurally ordered tubular SCC films were fabricated within glass tubes via solvent evaporation-induced vertical deposition. The optical interference effects of these tubular films were systematically investigated with tunable glass tube internal diameters and colloidal suspension concentrations (mass/volume ratios). The feasibility of tubular films in the OPLI system was further quantitatively assessed using ethanol-water solutions of different concentrations. Meanwhile, their stability was evaluated through OT measurements both within and between batches. Moreover, the binding and dissociation processes of human immunoglobulin G (hIgG) to *Staphylococcus aureus* protein A (SPA)-modified tubular SCC films were monitored in real time and compared with previously reported equilibrium binding constants, thereby validating the system's feasibility. This strategy of combining curvature bionic design with photonic crystal technology, building an analytical platform with dynamic, label-free and real-time monitoring capabilities for the study of biological microenvironments.

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MoO_{3-X}/COF/TiNT heterojunction photocatalyst used in photocatalysis

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Tianyang Yuan

Titanium nanotube (TiNT) is widely used in photocatalysis, which can combine with other semiconductors, forming heterojunctions. Molybdenum oxide with oxygen vacancy (MoO_{3-X}) is popular in photocatalytic field because of its outstanding light adsorption ability and narrow band gap. Covalent Organic Framework (COF) material is emerging photocatalytic material due to its tunable porous structure, high surface area and excellent optical property. In this work, we designed a three-phase heterojunction (MoO_{3-X}/TiNT/COF), and plan to use it in photocatalytic water splitting and CO_2 reduction. In our work, we are synthesis a brand new COF, which is synthesized by “click chemistry”.

Organic scaffold and Nanomaterial synthesis for applications in photocatalytic water splitting or CO2 reduction

Department of Chemistry and Materials Science, Xi’an Jiaotong-Liverpool University
Qingran Chang

To solve the challenges of the shortage of traditional fossil fuels and environmental pollution, scientists are actively seeking renewable and clean energy alternatives. Among numerous alternative energy sources, hydrogen has attracted much attention due to its high energy density and wide application. Photocatalytic hydrolysis is currently a relatively popular method for hydrogen production. Photocatalytic reactions are processes that use light energy to drive chemical reactions, typically occurring on the surface of semiconductor materials. When light irradiates a semiconductor, photogenerated charge carriers are produced in the valence band (VB) and conduction band (CB), participating in redox reactions. This project is designed to develop a photocatalyst for hydrogen production via hydrolysis, consisting of titanium nanotubes, manganese-cadmium sulfides, and covalent organic frameworks (COF).

Investigation of the Structure-Activity Relationship and Single-/Two-Photon Polymerization Properties of Double Benzylidene Ketones

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Photoinitiators (PIs) generate reactive species upon light absorption to initiate polymerization. The rise of LED-based photocuring, visible-light LEDs, and NIR lasers has intensified demand for PIs sensitive to both single- and two-photon processes. Double benzylidene ketones (DBKs) offer an attractive scaffold due to their core conjugation system formed via a one-step aldol condensation, enabling high yields and straightforward synthesis. However, DBK-based PIs often suffer from low solubility in industrial resins, and the correlation between their performance in one-photon polymerization (OPP) and two-photon polymerization (TPP) remains underexplored.

In this study, 14 novel DBK derivatives were synthesized. Through strategic modifications—introducing terminal/side-chain substituents with distinct electronic effects (e.g., H/*tert*-butyl; F/N,N-dimethylamino), modulating alkyl chain length (methyl, ethyl, *n*-butyl, *n*-dodecyl), and incorporating varied conjugated ketone moieties (cyclopropanone/cyclopentanone/cyclohexanone)—we systematically established multi-dimensional structure-activity relationships governing their photophysical and photochemical properties. We elucidated their intrinsic radical polymerization and photobleaching mechanisms. Their performance in single-photon polymerization was evaluated under visible light (405–520 nm), and their two-photon polymerization (lithography) performance was assessed under 780 nm femtosecond laser irradiation.

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Tandem Oppositely Charged Nanoclay Membranes with 2D Nanofluidic Channels for Osmotic Energy Conversion

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Reverse electrodialysis (RED) is a notable method to harvest osmotic energy, as it can directly convert chemical energy into electrical energy. [1] The emergent 2D nanoclay membranes consist of ultrahigh-density 2D charged nanochannels, which therefore possess a high flux and low resistance for ion transport, serving as promising ion-selective membranes for osmotic energy conversion by RED method. [2.3] However, the fabrication of tandem stacks using 2D nanoclay membranes with opposite selectivity to simultaneously utilize both cations and anions for osmotic energy conversion remains a challenge. Here, we use negatively charged 2D montmorillonite (MMT) and positively charged 2D layered double hydroxide (LDH) membranes to fabricate a tandem stack for efficient osmotic conversion. These two kinds of nanoclay membranes are prepared by vacuum filtration-assisted assembly of liquid-exfoliated nanosheets and charged cellulose nanofibers. The LDH membrane exhibits an anion transference number of over 0.70, while the MMT membrane exhibits a cation transference number of over 0.80, and both of them demonstrate a surface-charge-governed ion transport property. A full-cell formed by one pair of 2D MMT and LDH membrane in series generates a maximum output power density of 1.14 W m^{-2} under 50-fold salinity gradient of 0.01/0.5 M KCl without any contribution of redox potential difference, which is much higher than that of any individual membrane. A tandem stack composed of 17 cells achieves a high output voltage of 1.29 V, which can be used as a power source for a calculator. [4] Our results indicate that the charged 2D nanoclay membranes can serve as promising candidates for the ion-selective membranes in RED stack to achieve efficient osmotic energy conversion

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Ternary Hybrid Materials Based on the Photoinduced Cationic Polymerization of Functional Twin Monomer and Epoxides

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Organic–inorganic hybrid materials combine organic and inorganic components at the nanoscale, offering excellent mechanical strength, thermal stability, and flexibility for applications in optoelectronics, biomedicine, and energy. Traditional sol–gel methods often cause shrinkage and cracking due to small-molecule by-products. Twin polymerization provides a one-step route to form nanoscale (0.5–3 nm) hybrid networks without phase separation. Incorporating functional groups into twin monomers and using environmentally friendly photo-initiated polymerization enables efficient, controllable fabrication of high-performance hybrid materials with superior comprehensive properties.

In this report, homogeneous ternary silicone hybrid materials composed of phenolic resin, disubstituted polysiloxane, and crosslinked epoxy resin were rapidly prepared via photoinduced cationic ring-opening copolymerization of a twin monomer, 2-methyl-2-(3-glycidoxypropyl)-4H-1,3,2-benzodioxasiline (MGS), and an epoxy monomer, 3,4-epoxycyclohexylmethyl-3′,4′-epoxycyclohexane (EPOX). The monomers exhibited excellent compatibility without phase separation during storage. Upon light irradiation, MGS polymerized to form polysiloxane and phenolic resin, while EPOX acted as a crosslinking agent. The reaction mechanism was verified by FTIR, solid-state ^{13}C and ^{29}Si NMR, and XPS analyses. SEM images confirmed a homogeneous morphology with high optical transparency. This work demonstrates a simple, room-temperature photopolymerization method for fabricating transparent ternary hybrid materials with promising potential in coatings, photoresists, and optical applications.

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New Water-Soluble Coumarin-Ketone-Pyridium Salts Photoinitiators for Antibacterial Coatings under Visible LED Photocuring

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UV-photocured antibacterial coatings have gained widespread attention due to their rapid curing, energy efficiency, and environmental benefits. However, commercially available water-soluble photoinitiators, such as Irgacure 2959, exhibit poor compatibility with visible LED light sources, limiting their application in green and sustainable photopolymerization systems. Additionally, the integration of effective antibacterial functionality without compromising biocompatibility remains a challenge, especially when using metal-based agents that raise toxicity concerns. Therefore, the development of visible-light-sensitive, water-soluble, and inherently antibacterial photoinitiators is highly desirable.

To address these issues, we designed and synthesized two novel coumarin-ketone-pyridinium salt photoinitiators, CPS-I and CPS-TsO, featuring different anions. These compounds exhibit strong absorption in the 365-425 nm range and enable efficient free radical polymerization under visible LED irradiation when combined with N-phenylglycine as a co-initiator. Notably, CPS-TsO demonstrated superior water solubility and initiation performance in both thin and thick film polymerizations. Beyond their high photoreactivity, both photoinitiators and the resulting coatings exhibited significant antibacterial activity against E. coli and S. aureus, with inhibition rates exceeding 97%. Importantly, hemolysis tests confirmed excellent blood compatibility of the photoinitiators and cured coatings, highlighting their potential for biomedical and hygienic coating applications. This work provides a dual-functional photoinitiating system that combines visible LED curability with intrinsic antibacterial properties, offering a promising strategy for next-generation environmentally friendly coatings.

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Strategies for Enhancing Osmotic Energy Conversion in 2D montmorillonite-based Nanofluidic Membranes

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Osmotic energy from the salinity difference between seawater and river water offers a promising route for sustainable power generation. However, the conversion efficiency of nanofluidic membranes is limited by the tradeoff between ion selectivity and ion permeability. [1,2] To address this challenge, researchers have developed light-responsive nanofluidic membranes and modulated the interlayer spacing of 2D channels to enhance osmotic energy conversion. In our recent studies, we explored two effective strategies. First, we fabricated photothermal-responsive hybrid membranes by integrating black phosphorus (BP) nanosheets with montmorillonite (MMT) nanosheets and reinforcing by cellulose nanofibers (CNF). [3] Under 400 mW/cm^2 simulated sunlight, the surface temperature of the membranes increased due to the photothermal effect of BP nanosheets, boosting the maximum power density from 4.84 to 5.31 W/m^2 at a 50-fold KCl salinity gradient. Second, we modulated the interlayer spacing of MMT-based membranes by partially substituting Na^+ with $Ru(bpy)_3^{2+}$ cations. [4] The cation intercalation increased the interlayer spacing, which improved ion flux while maintaining cation selectivity, delivering a maximum power density of 5.30 W/m^2 under a 50-fold KCl gradient, and up to 10.05 W/m^2 in hypersaline conditions. These two approaches demonstrated that the introduction of external energy and modulation of interlayer spacing are both promising strategies to enhance osmotic energy conversion in 2D nanofluidic membranes.

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Dual S-scheme g-C_3N_4/Fe_3O_4/In_2O_3/MoS_2 magnetic nanocomposite for enhanced visible-light-driven tetracycline degradation

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A novel quaternary nanocomposite (g-C_3N_4/Fe_3O_4/In_2O_3/MoS_2) was synthesized via a synergistic hydrothermal-ultrasonic wet chemistry route. Various advanced characterization techniques were employed to comprehensively characterize the nanocomposite. The photocatalytic efficiency of the nanocomposite was investigated by using tetracycline (TC) antibiotic as a model pollutant. The quaternary nanocomposite showed remarkable photocatalytic degradation efficiency of TC (94.1% in 240 min visible-light illumination) under natural pH (6.17) and low catalyst dosage (0.2 g/L) with $k = 0.0106\ \text{min}^{-1}$. Critical variables include catalyst type, dosage (0.05-0.5 g/L), TC concentration (5-40 mg/L), and pH (5-9) were systematically investigated to maximize tetracycline mineralization efficiency. Quenching experiments indicated $\bullet O_2^-$ served as the main active radical. Furthermore, the g-C_3N_4/Fe_3O_4/In_2O_3/MoS_2 nanocomposite demonstrated robust stability and rapid magnetic separation over five cycles. The degradation pathways were deduced based on possible degradation intermediates. The excellent performance of the quaternary nanocomposite can be ascribed to expanded visible-light absorption and suppressed charge-carrier recombination via a dual S-scheme heterojunction. Consequently, this novel nanocomposite shows great potential for efficiently removing emerging organic contaminants from aqueous solutions.

Effects of Allyloxy Substitution on Photochemical Properties of Thioxanthones and Their Application in Visible-LED Photopolymerization

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Photoinitiators are essential for advanced photopolymerization technologies. Thioxanthones, particularly ITX, serve as important Type II photoinitiators due to their efficient radical generation via hydrogen abstraction. However, ITX faces critical limitations: mutagenicity, short absorption wavelength (<400 nm), and high migration. Although 1,4-dimethoxy substitution red-shifts absorption to 425 nm, it reduces photolytic efficiency. To overcome these issues, here we designed and synthesized thioxanthone derivatives featuring strategically substituted allyl and propyl groups at the 1,4-positions of the thioxanthone core. Our results reveal that the 1-position allyloxy group enhances electron delocalization, modifying excited-state dynamics to boost photolysis rates and polymerization efficiency. This design simultaneously achieves strong visible-light absorption (ε_{425nm}>800 $M^{-1}cm^{-1}$) and a 90 % reduction in migration compared to ITX. The work demonstrates a rational strategy to develop high-performance, low-migration photoinitiators for visible LEDs curing systems. In summary, systematic structural modifications at the 1-position of thioxanthone derivatives revealed critical advantages of allyloxy over propoxy substituents for visible-light-driven photopolymerization.

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Gradient Electroactive Hydrogel Scaffolds for Wireless Electrical Stimulation-Mediated Nerve Repair

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Peripheral nerve injury (PNI) is a common clinical neurological condition resulting in partial or complete loss of sensory, bringing great burden to patients' lives[1]. Electrical stimulation and physical gradient serve as critical guidance cues in nerve repair[2-3]. Hydrogels containing these clues exhibit great potential for nerve repair[4][5]. However, current research on combining multiple gradients to regulate neuronal behavior is still limited, and few studies have combined ultrasound stimulation with multiple physical gradients to promote neural repair.

In this research, we fabricated NAGA/BSNF/rGO/BTO electroactive hydrogels exhibiting multiple gradient properties. Silk fibroin solution was processed into beta-sheet rich silk fibroin nanofibers(BSNF) via thermal concentration method. BSNF was dissolved and mixed with acryloyl glycinamide(NAGA), reduced graphene oxide(rGO) and barium titanate(BTO), followed by addition of cross-linking agent and initiator. An external DC electric field was applied to induce the negatively charged BSNF and rGO migrate towards the anode in the hydrogel matrix. Then the gradient hydrogel was synthesized by thermal curing at 80 °C.

The fabricated electroactive hydrogels exhibit multiple physical gradient properties. The hydrogel possesses a mechanical gradient, with a lower modulus corresponding to regions of higher BSNF content. The overall storage modulus of the hydrogel is comparable to that of native neural tissue. Furthermore, the hydrogel exhibits gradients in both conductivity and morphology. Live/dead staining confirmed the material's good biocompatibility. The presence of piezoelectric materials allows the material to convert ultrasound into electrical stimulation. The SH-SY5Y cells were cultured on the hydrogel. The results demonstrated that the physical gradients guide directional cell growth, while ultrasound stimulation significantly enhances cell proliferation and neuronal differentiation. This study proposes a new strategy for designing nerve repair scaffolds potentially enabling coordinated modulation of multiple microenvironmental cues.

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Construction and Preliminary Investigation of Non-Immersed Photocatalytic Hydrogen Evolution System

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Photocatalytic water splitting is a promising single-step route to solar H_2 production that avoids direct CO_2 emissions and has been intensively studied for decades. [1,2] However, reactor-level kinetics—photon delivery, mass transfer and product removal—often limit practical performance, making reactor and system design as important as materials. [3] Non-immersed, surface-confined architectures can improve light access and gas release but require continuous water supply and robust catalyst immobilization. [4]

We demonstrate a capillary-fed, non-immersed system in which a porous melamine sponge supplies water by capillarity while a cryogel immobilizes the photocatalyst in the sponge's upper layer. The sponge + gel create an ultrathin conformal liquid film that (i) supplies water to active sites and (ii) greatly reduces hydrodynamic resistance to gas release versus submerged geometries. Catalyst is distributed into the near-surface skeleton, forming a quasi-3D dispersion that increases accessible sites while matching photon penetration.

The system delivers a several-fold increase in areal H_2 production and apparent quantum efficiency versus submerged controls. Mechanistic tests indicate the gain stems from higher photon flux at the active surface (reduced liquid attenuation) and relieved mass-transfer limits during product removal. These results show capillary-fed, non-immersed architectures can substantially boost areal efficiency and support scalable solar H_2 production.

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Integrated Photothermal Evaporation and Photocatalytic Degradation/removal of Microplastics Using Titanium Mesh Supported TiO_2 Nanotube Arrays

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The widespread existence of microplastics (MPs) in aquatic environment possesses a significant challenge of water contamination and highlighting the need for sustainable purification methods. Herein, we report an integrated strategy that couples solar-driven photothermal evaporation with photocatalytic degradation of microplastics using titanium mesh modified with anodically grown TiO_2 nanotube arrays (TMiP-TNTs) [1]. The TiO_2 nanotubes provide a high surface area for light absorption and catalytic activity, while the metallic mesh substrate ensures efficient heat conduction for localized water evaporation [2, 3]. Environmentally relevant polyethylene (PE) fragments were dispersed in aqueous suspensions and exposed to simulated solar irradiation in the presence of TMiP-TNTs. The system simultaneously achieved clean water production through interfacial evaporation and degradation/removal of MPs, as confirmed by UV-Visible spectroscopy, Fourier transmission infrared (FTIR), Compound Microscope, Scanning electron microscopy (SEM), along with Gas chromatography- Mass spectrometry (GC–MS). Results indicate that the synergistic action of photothermal heating and photocatalysis accelerate the polymer surface oxidation, fragmentation, and mineralization. This study demonstrates a dual-function water treatment platform that not only addresses the removal/ degradation of microplastics but also contributes to sustainable clean water generation, offering a new direction for integrated environmental remediation technologies.

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Click Gel Polymer Electrolyte Achieving Liquid-Comparable Conductivity

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Gel polymer electrolytes (GPEs) offer a promising route toward safer and more flexible energy devices, yet their ionic conductivity is often compromised by the disordered and heterogeneous nature of conventional polymer networks.[1] In this study, we introduce a precision network engineering strategy based on photoinitiated thiol-ene click chemistry, which enables the formation of chemically crosslinked polymer gels with high structural uniformity, suppressed crystallinity, and minimal unreacted segments. The resulting network achieves an ultralow gelation threshold (5 wt%) and demonstrates activation energies for ion diffusion as low as 5.8 kJ·mol^{-1}—comparable to liquid electrolytes and significantly lower than that of conventional GPEs (up to 28.8 kJ·mol^{-1}). This structure supports near-liquid-level conductivity across 9 different electrolyte systems. When integrated into devices, the click-GPE enables long-term cycling in lithium-metal batteries (83% capacity retention over 1000 cycles) and record efficiency (11.3%) in quasi-solid-state dye-sensitized solar cells. These findings offer a scalable and generalizable route to overcome the intrinsic conductivity limitations of GPEs, paving the way for next-generation quasi-solid-state electrochemical technologies.

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Molecular linker engineering CdS/$Cu_2ZnSn(S,Se)_4$ interface for efficient photovoltaics

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A high-quality CdS/$Cu_2ZnSn(S,Se)_4$ (CZTSSe) heterojunction interface is considered essential for obtaining efficient CZTSSe solar cells. However, the inherent surface defects of CZTSSe films, along with the non-uniform nucleation of CdS, pose non-negligible challenges to constructing a high-quality heterojunction. In this work, we proposed an innovative molecular linker strategy for dual-sided modulation of CdS/CZTSSe heterojunction, simultaneously passivating CZTSSe surface defects and regulating uniform CdS nucleation. We systematically screened 10 amino acid-based molecules and identified cysteine (Cys) as exhibiting outstanding bifunctional properties. The introduction of Cys improved device efficiency from 10.35% to 11.15% in the dimethylformamide (DMF) solution preparation system, and significantly enhanced efficiency from 11.22% to 12.79% in the 2-methoxyethanol (MOE) solution preparation system, demonstrating the broad applicability of this strategy. Experimental and theoretical analyses revealed that the passivation effect of Cys primarily originated from the effective interactions between its thiol (-SH) and amino ($-NH_2$) groups and the intrinsic surface defects of CZTSSe, leading to stable defect passivation. Meanwhile, the outward-facing carboxyl (-COOH) group in Cys helped homogenize the nucleation sites on the CZTSSe surface, promoting the dense and uniform nucleation of CdS. This work established a scalable strategy for interfacial optimization, advancing the development of CZTSSe thin-film photovoltaic devices.

Photo-Plasma Relay Catalysis for Molecular Oxygen Activation

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Clean energy driven molecular oxygen activation (MOA) is crucial for the advancement of green oxidation technology and sustainable chemistry. While photocatalysis and plasma catalysis have long been regarded as promising green means for MOA, it remains largely unexplored by which mechanism these two processes can be combined to surpass the capability of each individually for efficient MOA. In this study, we couple photocatalysis with solution plasma catalysis by using oxides suspensions as the mediator, and elucidate the specific relay mechanism of photo-plasma catalysis for MOA. Among the various oxides tested, TiO_2 with an anatase-rutile mixed composition performs the best for photocatalysis-solution plasma synergy, resulting in 11.3 times and 5.6 times higher rate of oxidative decomposition of bisphenol A than that of photocatalysis and plasma catalysis alone, respectively. The solution plasma in synergy

with UV excitation boosts the yield of $\cdot O_2^-$ on rutile TiO_2 and the conversion of $\cdot O_2^-$ to $^1O_2$ on anatase TiO_2, thereby promoting a relay MOA at the anatase-rutile interface. Our findings on the relay mechanism of MOA and the promotion of synergy by the heterojunction interface open new avenues for clean energy driven catalytic reaction with heterojunction materials.

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Highly Efficient Sunlight-Driven CO2 Hydrogenation to Methanol Over supported NiZn intermetallic catalyst on α-Al_2O_3

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The capture of atmospheric carbon dioxide (CO_2) using renewable energy sources has emerged as an increasingly critical challenge in the quest for "carbon neutrality," against the backdrop of rising atmospheric CO_2 levels. However, CO_2 is chemically inert and thermodynamically stable, and its widely employed hydrogenation conversion typically requires harsh reaction conditions such as high temperature and high pressure, demanding significant energy input and specialized equipment. This study demonstrates a solar-driven photothermal conversion system that facilitates CO_2 hydrogenation under mild conditions (1 atm, 230 °C) using a supported NiZn intermetallic catalyst on α-Al_2O_3. A remarkable methanol production rate of 393 mmol g^{-1} h^{-1} was achieved with 100% selectivity towards methanol in the organic products. This catalyst attained the highest reported production rate in a continuous-flow reactor powered solely by sunlight, showcasing advantages such as low cost and simple preparation. This work represents a significant stride towards fully solar-driven chemical energy storage.

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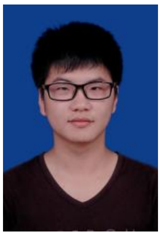
Ni-doped ZnCdS in Liquid-phase Z-type reaction system for photocatalytic overall water splitting



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In recent years, hydrogen has been regarded as an important way to address the decline in stone energy reserves and the deterioration of the environment[1, 2]. Solar-driven photocatalytic overall water splitting (OWS) is regarded as one of the most promising methods for effectively utilizing solar energy and obtaining renewable hydrogen. It is worth mentioning that the Z scheme OWS system has been regarded as an ideal strategy for achieving OWS due to its advantages in reducing the thermodynamic prerequisites of semiconductor photocatalysts. Among various hydrogen evolution photocatalysts, sulfides represented by ZnCdS often exhibit excellent photocatalytic hydrogen evolution performance. However, the insufficiency of its durability greatly limits its application as a hydrogen evolution catalyst in Z-scheme water splitting system. For this purpose, we studied the OWS reaction in the $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$ system with Ni-doped ZnCdS as hydrogen evolution catalyst and $BiVO_4$ as oxygen evolution catalyst. It has been found that sulfides represented by Ni-doped ZnCdS in system readily react with REDOX media to form complexes. This significantly inhibits the performance of the catalyst. Meanwhile, the research results show that complexes tend to form on the hole-rich crystal planes of the hydrogen evolution catalyst and the electron-rich crystal planes of the oxygen evolution catalyst, which can alleviate the negative impact of the complex on the performance of photocatalytic water splitting. The results show that by passivating the surface, the photocatalytic performance can be effectively improved, achieving a yield of 109 μmol/25 mg/h, with a hydrogen-oxygen ratio of 2.09:1.

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High-performance quantum dot light-emitting diodes

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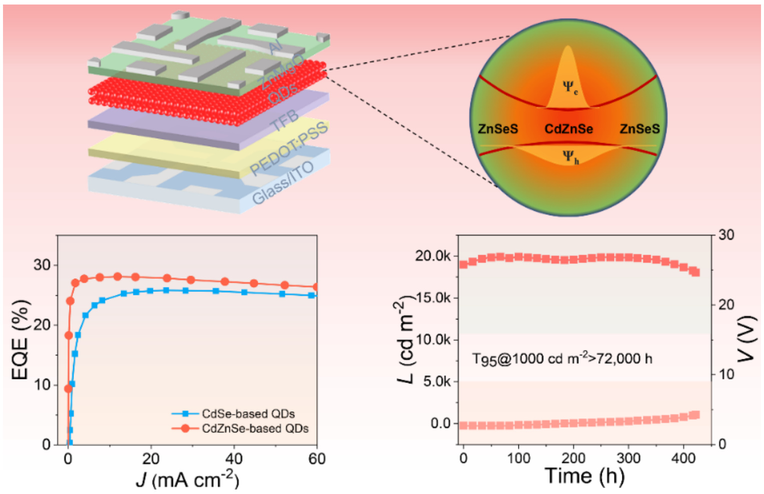
Solution-processed quantum dot (QD) light-emitting diodes (LEDs) hold great potential as competitive candidates for display and lighting applications. Their outstanding performances, including high efficiency, long-term device stability, and suppressed efficiency roll-off, stem from QD core/shell structure engineering. The composition and structure of QDs regulate the carrier dynamics, flattening the energy landscape between the QD layer and charge transport layers, thereby enhancing exciton radiative recombination. The resulting devices exhibit external quantum efficiencies of 28.1% (red), 30.7% (green), and 24.3% (blue). Our red and blue devices also show excellent stability, with extrapolated T_{95} lifetimes (at an initial brightness of 1,000 cd m^{-2}) of 72,968 h and 21,900 h, respectively. The outstanding performance of these full-colour QD-LEDs is a critical step towards achieving the commercial realization of QD-LED display technology.



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Magnetic Cilia Microreactor Array for Rapid Trace Proteomics Digestion

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Based on trace proteomics, traditional sample preparation has long hindered the dissection of cellular heterogeneity. Although shotgun proteomics coupled with LC/MS/MS stands as the gold standard for global protein identification, its enzymatic digestion step is inefficient and time-consuming; moreover, overnight free enzyme digestion causes further sample loss and inconsistent results, reducing peptide coverage and the reliability of mass spectrometry data.

Recently, researchers have raced to develop faster digestion strategies: microwave-assisted methods cut time to 5 min[1], ultrasound to 1 min[2], and pressure cycling to under 5 min[3]. Immobilized enzyme reactors (IMERs) further addressed enzyme autolysis and stability by anchoring trypsin to nanoparticles, monolithic columns, or fibers—yet even these had limits. Gold nanoparticle-based IMERs took 12 h to reach just 40% BSA coverage[4] but still fell short of high-throughput, trace-sample needs.

In this study, we developed a magnetic cilia-based IMER (Try@cilia) integrated with a microdroplet array chip—with the magnetic responsiveness of the cilia emerging as a key functional element. Under a rotating magnetic field, Try@cilia in droplets actively rotate, creating dynamic mixing that supercharges digestion: 30 trace protein samples processed in parallel, all in 1 min. For 0.2 μg HeLa cell lysate, Try@cilia IMER detected 4,381 protein groups (33% over overnight free enzyme digestion) and doubled matched peptides. Critically, it eliminates the twin nightmares of traditional methods: no more sample loss for low-input samples, no more batch-to-batch variation.

By turning magnetic cilia into active digestion drivers, we've unlocked the potential of trace proteomics, making high-quality, high-throughput analysis of rare cells or limited samples finally accessible.

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Effect of Co-Dissolved Organic Compounds on Photocatalytic Degradation of Simetryn, Prometryn, Metolachlor, and Sulfometuron methyl

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This study investigated the influence of representative co-soluting organic compounds (cossolutes) on the photocatalytic degradation efficiency of herbicides (simetryn, prometryn, metolachlor, and sulfometuron methyl) in river water scenarios. Based on the characteristic categories of major dissolved organic matter present in river water, glucose (saccharide), sodium dodecyl sulfate (SDS, surfactant), and glycine (amino acid) were selected as model representative cossolutes.

Results unequivocally demonstrated that the presence of these cossolutes significantly inhibited the photocatalytic degradation kinetics of the target herbicides. Among them, glucose exhibited the most pronounced inhibitory effect, reducing the hydroxyl radical-dominated degradation rate constant (k_{obs}) to approximately one-quarter (≈1/4) of that observed in the cossolute-free control system. A distinct sequence of inhibition strength was observed for the cossolutes: glucose > SDS > glycine.

Based on these findings, when evaluating the photocatalytic degradation efficacy or designing engineering solutions for herbicides in riverine matrices, consideration should be given to applying a safety factor of approximately 4 to account for the potential inhibitory effects from co-soluting organic matter. Notably, the observed inhibition sequence (glucose > SDS > glycine) aligns with the ranking of rate constants ($k_{\bullet OH}$) for the reaction of these compounds with hydroxyl radicals (•OH). This strongly indicates that organic cossolutes exhibiting high reactivity towards reactive oxygen species (ROS), particularly •OH, exert a more significant competitive inhibitory effect on the photocatalytic degradation kinetics of target pollutants, such as herbicides.

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Design of Photothermal Interfacial Evaporation Structures Based on Porous Materials and Synergistic Mechanisms of Gradient Photothermal Management

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The global freshwater shortage is a critical issue affecting many regions, driven by population growth and climate change [1]. Solar-driven interface evaporation has emerged as a sustainable and energy-efficient strategy to address this problem, utilizing abundant solar energy for water purification [2]. Recently, three-dimensional (3D) interfacial evaporators have been reported with evaporation rates surpassing the theoretical limit of 2D evaporators (~1.47 $kg \cdot m^{-2} \cdot h^{-1}$) [3]. It has been reported that the 3D evaporator could obtained enhanced environmental energy by reducing the projection ratio (the ratio of the projected area to the actual evaporation area), which is beneficial to improving the solar evaporation rate [4]. However, a key challenge in practical applications is the accumulation of salt crystals on the evaporator, which will reduce solar absorption, obstruct water transport, and degrade evaporation performance. The horizontal water channel and vertical channel wall could accelerate the mass transfer and diffusion, avoiding the excessive concentration of salt. However, excessive water transfer may increase heat loss to the bulk water, highlighting the need to balance water transport with thermal management in 3D evaporators. Based on this, the research group took the design of 3D photothermal materials and the mechanism of photothermal regulation as the direction. The photothermal materials are loaded onto porous structures (such as phenolic foam, plant fruits) to construct evaporators. The influence of the structural design on photothermal properties was preliminarily explored. Through simulation calculations, the effects of pore size and the structure of the evaporator on photothermal and salt resistance were revealed [5-6].

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CuO@Fe_2O_3 Nanotubes Enabling Efficient Semiconductor-Sensitized Thermal Cell via Charge Separation and Band Structure Prediction

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[Introduction]

Substantial amounts of low-grade heat are wasted in the environment due to the lack of efficient and cost-effective conversion technologies. To tackle this challenge, Semiconductor-Sensitized Thermal Cells (STCs) represent a novel approach for directly converting low-grade heat into electricity. The distinctive properties of STCs, including their rechargeability, present new opportunities for the effective utilization of abundant low-temperature thermal energy. In this STC, we introduced *pn* junctions formed by *p*-type CuO and *n*-type Fe_2O_3, which enhance electron–hole separation. CuO is simultaneously structured into hollow nanotubes to enlarge the electrode–electrolyte interface and increase the heat-induced current density.

[Experimental]

CuO@Fe_2O_3 nanotubes designed as a hole-charge-separation layer were synthesized via a hydrothermal method. CuO nanotubes were grown on a Cu substrate and subsequently coated with Fe_2O_3 to form the working electrode. Electrochemical measurements were conducted in a CuCl/$CuCl_2$ electrolyte solution dissolved in PEG600. To further elucidate the electronic properties, we attempted to elucidate the band structure by combining the results of Mott–Schottky measurements with density functional theory (DFT)-based calculations. After assembling a full cell using an FTO counter electrode, its thermal energy conversion performance was evaluated.

[Results and Discussion]

TEM observation confirmed that Fe_2O_3 nanoparticles were deposited on CuO nanotubes. Among samples with 5, 10, 15, and 20 minutes of CuO growth, the 10-minute sample exhibited the best electrochemical performance, showing superior discharge and recovery. At 40 °C and an active surface area of 0.126 cm^2, it produced an open-circuit voltage of 0.58 V and a short-circuit current of 4.24 μA. Under a constant 20 nA discharge and 4 h of open-circuit monitoring, it demonstrated stable recovery over 120 cycles. Furthermore, the structural model combining CuO (111) and Fe_2O_3 (110) surfaces was validated as feasible through DFT calculations.

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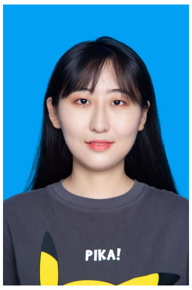
Facet-Engineered Au_1/CeO_2 Single-Atom Catalysts toward Efficient Room-Temperature Photothermal CO Oxidation



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Single-atom catalysts supported on metal oxides have shown great promise in heterogeneous catalysis. However, how the exposed facets of oxide supports precisely regulate catalytic performance through interactions with metal single atoms—particularly their influence on lattice oxygen activity—remains a critical and underexplored scientific question. Herein, we employed a continuous-flow liquid plasma technique to precisely anchor Au single atoms on ceria (CeO_2) supports with different morphologies, predominantly exposing the (110), (111), and (100) facets. In the photothermal catalytic oxidation of CO, we discovered a decisive influence of the support facet on catalytic activity. Remarkably, Au_1/CeO_2-R(110) exhibited exceptional room-temperature photothermal catalytic performance, achieving 99% CO conversion under simulated sunlight (Xe lamp irradiation) with no degradation over 50 hours. In sharp contrast, Au_1/CeO_2-C(100) showed only 1% conversion under identical conditions. The photothermal catalytic process was investigated in detail using O_2-TPD, in situ Raman, and in situ IR spectroscopy. The results indicate that under light excitation, Au single atoms on different facets induce varying degrees of lattice distortion and an increase in the M–O bond length of neighboring Ce–O species. This effect is most pronounced on the (110) facet, revealing strengthened metal–support interactions under photothermal conditions. This process effectively activates the lattice oxygen of CeO_2, thereby significantly enhancing the catalytic oxidation performance. This work provides atomic-level insights into the crucial role of support facet effects in determining the lattice oxygen activation mechanism in single-atom catalysts. It underscores the importance of support surface structure engineering and paves the way for the rational design of highly efficient single-atom catalysts with highly active lattice oxygen.

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The Self-Sustaining Fenton Reaction: A Biocatalytic System for In Situ H_2O_2 Generation

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This study aimed to overcome the primary bottlenecks of the conventional Fenton process—namely, the reliance on continuous external H_2O_2 addition, the requirement for highly acidic conditions, and the formation of iron sludge. To achieve this, a novel self-sufficient hybrid catalyst (Fe-g-C_3N_4/GOD) was synthesized by immobilizing glucose oxidase (GOD) onto a composite of Fe_3O_4 nanocrystals embedded in mesoporous graphitic carbon nitride (g-C_3N_4) nanosheets. Glucose, an abundant and benign substrate often present in wastewater, was used as the internal fuel for the reaction.

Results unequivocally demonstrated that the Fe-g-C_3N_4/GOD system enables a self-sufficient photo-Fenton reaction through the in situ generation of H_2O_2 via the enzymatic oxidation of glucose. This system operates efficiently across a broad pH range (3.0–9.0), eliminating the need for harsh acidic adjustments. When applied to real industrial coking wastewater, the catalyst successfully converted the refractory effluent into a biotreatable state, increasing the BOD_5/COD ratio from 0.22 to a compliant 0.35.

Based on these findings, the system fundamentally addresses the economic and environmental drawbacks of traditional Fenton treatments. By eliminating the need for external chemicals (H_2O_2) and pH regulators, and by preventing iron sludge formation through photocatalytic Fe^{3+}/Fe^{2+} cycling and magnetic recyclability, the process offers a potential operational cost reduction of up to 90%. Notably, the underlying mechanism is a tripartite synergy: GOD enzymatically generates H_2O_2, the g-C_3N_4 photosupport accelerates the Fe^{3+}/Fe^{2+} cycle to sustain the reaction, and the embedded Fe_3O_4 serves as the iron source. This strongly indicates that integrating biocatalysis with photocatalysis provides a robust and sustainable solution for advanced oxidation, with hydroxyl radicals (·OH) confirmed as the dominant species driving pollutant degradation.

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Easy-to-Recycle Floating PVDF/TiO_2 Piezo-Photocatalytic Spheres for Agricultural Irrigation Water Purification

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The non-destructive conversion of powders into macroscopic materials, through diverse structural and functional design, holds immense scientific and applied potential, yet traditional methods struggle to achieve this objective. Herein, we developed a universal approach combining photocatalytic TiO_2 with highly non-reactive thermoplastic fluoropolymer polyvinylidene fluoride (PVDF) via simple mechanical methods. This yielded an organic composite suspension solid material exhibiting piezoelectric-photocatalytic effects, applied to degrade herbicides in aquatic environments. Compared to conventional catalysts, it demonstrated recyclability, high efficiency, and durability. Subsequent characterisation via SEM, TEM, XRD, FTIR, Raman spectroscopy, XPS, PFM, and electrochemical techniques confirmed its piezo-photocatalytic properties. Finally, LCMS investigations revealed potential degradation pathways for three herbicides within this material.

References

NO

Second-scale laser-driven synthesis of defect-engineered titanium-niobium oxide anodes for advanced lithium-ion batteries

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Rapid synthesis techniques have emerged as a highly promising approach for substantially enhancing production efficiency in the field of energy storage materials.[1] In this work, we present an innovative high-power fiber laser rapid reaction method for the synthesis of multicomponent metal oxides. Using $Ti_2Nb_{10}O_{29}$ (TNO) as the target material with TiO_2 and Nb_2O_5 as raw materials, this method shortens the sintering time from over 10 h in the traditional solid-state method to just 40 s. The ultrafast synthesis leads to lattice oxygen defects, promoting partial reduction states of Ti and Nb in TNO, which benefits the conduction kinetics of lithium-ions and electrons.[2] TNO synthesized at a power of 300 W (TNO-300) exhibits a seven-fold increase in electrical conductivity and a significantly improved Li^+ diffusion coefficient due to oxygen vacancies and lattice expansion.[3,4] Additionally, lattice defects result in obvious pseudo capacitance, contributing to a high-rate electrochemical response. This work provides a new high-efficiency strategy for developing high-performance energy-storage oxide materials.

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Matter Conversion and Clean Energy Catalysis

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Abstract

Our research group is dedicated to pioneering studies in key hydrogen energy science and technology, focusing on the core process of hydrogen production. By developing three complementary technical pathways—thermal catalysis, electrocatalysis, and photocatalysis—we aim to achieve efficient, low-carbon, and cost-effective hydrogen generation. This work provides the essential technological and material foundations for building a clean, sustainable energy future.

I. Research Context and Significance

Hydrogen energy, prized for its high energy density and clean, carbon-neutral properties, is regarded as the most promising secondary energy source of the 21st century. However, the efficient, green, and safe production of hydrogen remains the primary bottleneck for its large-scale application. Currently, over 95% of hydrogen is derived from fossil fuel reforming processes, accompanied by substantial carbon dioxide emissions. Consequently, developing novel, green hydrogen production technologies holds immense strategic importance.

Aligned with this major national strategic need and international academic frontiers, our research group has established a multi-pathway synergistic hydrogen production research system. This aims to overcome the limitations of existing hydrogen production technologies by addressing diverse application scenarios.

II. Primary Research Directions

Direction One: Thermocatalytic Formic Acid Decomposition for Hydrogen Production

Formic acid (HCOOH) serves as a liquid hydrogen carrier, offering advantages such as high hydrogen content, non-toxicity, non-flammability, and liquid state at ambient conditions for convenient transport. Its catalytic decomposition for hydrogen production represents an effective solution to hydrogen storage and transportation challenges.

Direction two: Electrocatalytic Water Splitting for Hydrogen Production

Utilising electricity generated from renewable sources to drive water splitting constitutes one of the most ideal pathways for producing green hydrogen. The core challenge lies in reducing the overpotentials of the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER), thereby enhancing overall energy conversion efficiency.

Direction Three: Photocatalytic Water Splitting for Hydrogen Production

Photocatalytic technology enables the direct conversion of solar energy into chemical energy, representing the most straightforward pathway for direct solar-to-hydrogen conversion and possessing immense application potential.

III. Summary and Outlook

Our research group has established a comprehensive and in-depth hydrogen production research platform by driving forward three key approaches: thermal catalysis, electrocatalysis, and photocatalysis. We are committed to achieving original breakthroughs at the fundamental science level while simultaneously advancing the translation of research outcomes into applied technologies. We warmly welcome outstanding students and scholars passionate about new energy materials and catalysis research to join us in exploring the mysteries of hydrogen science and working together towards achieving the goal of carbon neutrality.

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Efficient Water Treatment Using Packed-Bed Type Photocatalytic Reactors

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Photocatalytic water purification systems that decompose organic substances based on the strong oxidation ability of photocatalysis have been widely studied [1]. In efficient water purification systems, it is important to ensure the incident light effectively reaches the entire photocatalyst surface and that sufficient contact occurs between the photocatalyst and the target substances. This study aims to develop an efficient photocatalytic reactor based on the closed-packed bed systems using supported photocatalysts. Compared with the conventional photocatalysis using dispersed powders, this system offers the advantage of easy catalyst recovery. In the present work, to address the above issues, the photocatalyst concentration on the substrate was optimized so that light could penetrate to the deepest region of the photocatalyst layer. Regarding the gaps in the photocatalyst layers, the size of the substance was optimized. By optimizing the size and uniformity of the gaps in the photocatalyst substrate, efficient contact between the reactant and the photocatalyst is made possible, achieving high photocatalytic reaction activity. The size of the gaps in the photocatalyst layer were also optimized to ensure efficient contact between the reactant and the photocatalyst, resulting in enhanced photocatalytic activity.

In the experiment, photocatalyst was loaded onto transparent quartz substrate, fibers or flits. The concentration of the photocatalyst was adjusted by changing the TiO2 coating solution concentration. Packed-bed type photocatalytic reactors were fabricated by placing the substance with photocatalyst inside the reactor tubes. The reaction efficiency was evaluated under the specific flow rate of the water containing the model pollutant (Rh-B).

As a result, the packed-bed type photocatalytic reactors having photocatalyst with controlled concentrations showed high efficiency in decomposing pollutant, especially those present at extremely low concentrations. These findings provide a basis for developing treatment systems for low TOC level required in the ultra-pure water production fields.

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Efficient Photocatalytic Filters Based on Anodizing Process and Its Functional Applications

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Photocatalysts shows high oxidative power from photogenerated holes and have been applied in a variety of fields. Air purification by photocatalysis is one of important application fields, and numerous reports have been published. In photocatalyst-based air-purification devices, the key challenges are achieving high reaction activity and ensuring strong adhesion of the photocatalyst to the substrate. Here we show the results about the processes, in which these two issues are improved by using surface treatment of metal substrates based on anodization process. Anodic oxidation of metals such as Al can produce micro-and nanoscale surfaces, which can offer the large surface area and anchor effects.

The photocatalyst filter was prepared using an Al mesh. The Al mesh was anodized in 0.3 M oxalic acid at 10 °C under a constant voltage of 40 V. The Al mesh with the obtained porous oxide film was coated with and fixed with TiO_2. Adhesion strength was evaluated by a peel test using adhesive tape. The photocatalytic activity of the filter was evaluated using a photocatalytic activity measurement system with a UV-LED light source ($\lambda = 365$ nm) with a photoacoustic gas analyzer (INNOVA1412).

The anodized filter possessed a uniform and dense photocatalytic surface, which resulted in good performance. The TiO_2 coating exhibited excellent adhesion to the anodized substrate, confirming the device's robustness and potential for long-term use. The obtained photocatalytic filters were applied to the removal of ethylene for keeping freshness of the fruits, and inactivation of bacteria and virus. The photocatalytic filters can suppress the increase of ethylene concentration resulting the keeping freshness, and was effective for the sterilization of bacteria and virus.

The anodizing-based fabrication strategy successfully produces an efficient and durable photocatalytic filter. The results underscore its significant potential for dual functional applications in maintaining public health through air disinfection and ensuring food quality through produce preservation.

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Phase Transformation of TiO_2 Photocatalytic Powder: From Rutile to Anatase

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Abstract

Achieving the controllable transformation of titanium dioxide from the rutile phase to the anatase phase is a challenging topic in the field of materials science. This study successfully realized the controllable conversion of rutile phase TiO_2 to the anatase phase through a sequence of hydrothermal alkali treatment, acid washing, and calcination, constructing a unique core-shell structure of anatase phase encapsulated rutile phase (Anatase@Rutile).The experiment used commercial rutile TiO_2 as the raw material and underwent hydrothermal treatment at different times in a saturated concentration NaOH solution: Group A (7 h), Group B (16 h), and Group C (28 h), followed by acid washing and 500°C calcination treatment. The characterization results show that XRD and Raman analysis indicate that the B group sample achieved the optimal phase transformation effect, with anatase phase content of 33.3 wt.% and the formation of a clear two phases coexistence structure. SEM and TEM analysis confirmed that The B group sample exhibited typical core-shell structure characteristics, with rutile phase as the core and anatase phase as the outer shell. The successful construction of the core-shell structure provides an ideal platform for interface charge separation. This study not only broke through the limitations of traditional phase transition pathways and achieved the reverse transformation of rutile phase to anatase phase, but more importantly, successfully constructed a core-shell structure with interface synergy effect, providing new ideas for designing efficient TiO_2-based photocatalysts.

Keywords: Titanium dioxide; Phase transition; Core-shell structure; Rutile; Anatase; Photocatalysis

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