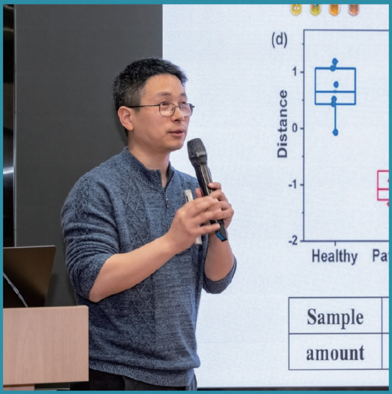
陕西师範大学
SHAANXI NORMAL UNIVERSITY

西安交通大學
XI'AN JIAOTONG UNIVERSITY

2025年12月
December, 2025

简报
Newsletter

新概念传感器与分子材料研究院
Institute of New Concept Sensors and Molecular Materials



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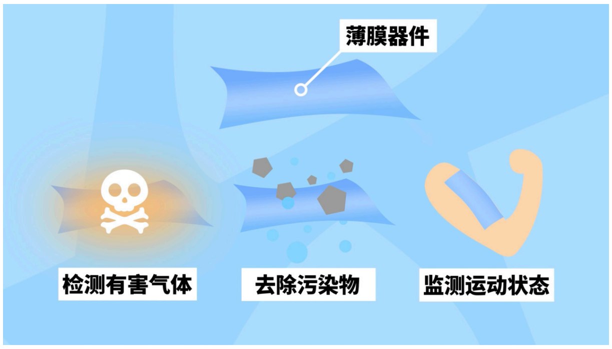
AMR 制作发布《界面聚合技术制备薄膜器件》科普视频

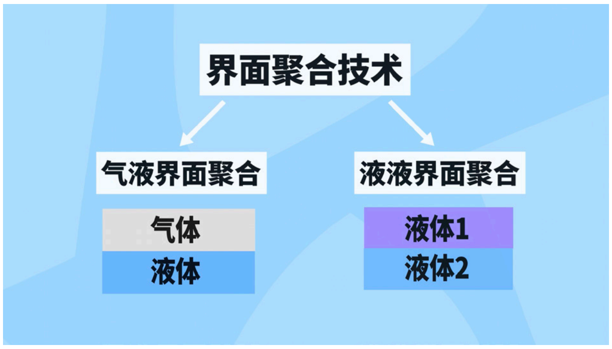
AMR releases science popularization video on Interfacial Polymerization Technology for Fabricating Thin-Film Devices

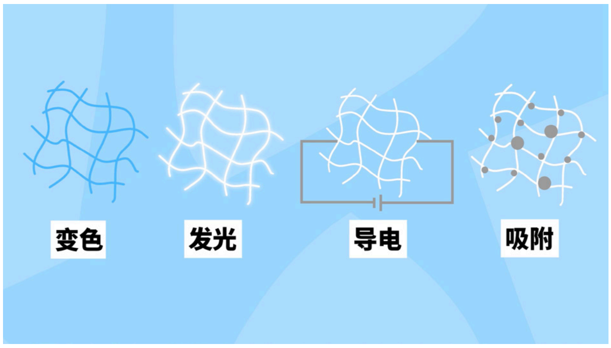
近日，Accounts of Materials Research 根据陕西师范大学新概念传感器与分子材料研究院房喻院士团队的 AMR 述评文章“Functional Thin Films: From Interfacial Preparation to Applications”制作了一条科普视频《界面聚合技术制备薄膜器件》，并在微信公众号“AMR 材料研究述评”上发布。

该述评文章介绍了利用气液界面聚合和液液界面聚合技术开发功能性薄膜方面取得的研究进展和应用场景，并展望了该领域面临的挑战和未来发展方向。

Accounts of Materials Research（简称 AMR）是由上海科技大学主办、与美国化学会（ACS）共同出版的国际学术期刊，聚焦材料科学与工程领域的评论性综述。







AMR科普视频系列：界面聚合技术制备薄膜器件

原创 AMR AMR材料研究述评 2025年12月2日 09:07 上海

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本期视频聚焦“界面聚合技术制备薄膜器件”，根据陕西师范大学化学化工学院房喻院士团队的*AMR*述评文章“Functional Thin Films: From Interfacial Preparation to Applications”制作。欢迎观看！

AMR科普视频系列

界面聚合技术制备薄膜器件

ACCOUNTS of materials research

Functional Thin Films: From Interfacial Preparation to Applications
Yan Luo, Xiaoyan Liu,* and Yu Fang*
Acc. Mater. Res. 2025, 6, 5, 600-614
DOI：10.1021/accountsmr.4c00400

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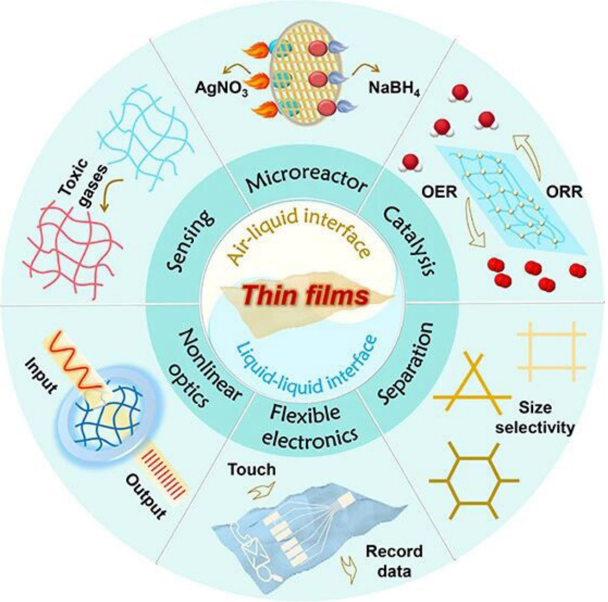


Recently, Accounts of Materials Research produced a science popularization video titled “Interfacial Polymerization Technology for Fabricating Thin-Film Devices” based on the AMR review article “Functional Thin Films: From Interfacial Preparation to Applications” by Prof. Fang Yu’s team from the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University, which was released on the official

WeChat account “AMR Materials Research Review”.

This review article presents research progress and application scenarios in developing functional thin-films using gas-liquid interface polymerization and liquid-liquid interface polymerization techniques, while also outlining the challenges and future development directions facing this field.

Accounts of Materials Research (AMR) is an international academic journal sponsored by ShanghaiTech University and co-published with the American Chemical Society (ACS), focusing on review articles in the field of materials science and engineering.

2025 届博士毕业论文答辩会举行

Class of 2025 Doctoral Dissertation Defense Session held

2025 年 12 月 3 日，陕西师范大学新概念传感器和分子材料研究院 2025 届物理化学专业博士研究生林思敏、翟宾宾和刘向泉三位同学分别以《多孔荧光分子材料的构筑、光物理性质和功能应用》《柔性功能纳米膜的可控构筑及其传感应用》和《有机多孔薄膜的界面限域制备、刺激响应性及其应用》为题进行了毕业论文答辩。

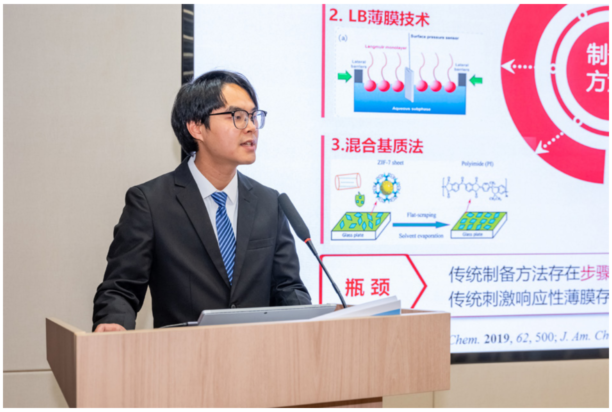
本次答辩由西安交通大学刘峰教授担任主席，西北工业大学孔杰教授、西北大学栾新军教授、西安交通大学何刚教授、西安电子科技大学吴巍炜教授担任答辩委员会成员。

在三位博士生的毕业论文陈述之后，评委专家对其进行了提问、评议和点评，并对毕业论文提出了完善修改意见。经讨论，答辩委员会一致认为三位博士生同学的毕业论文研究内容充分、逻辑合理，回答问题清楚，同意通过答辩并建议授予理学博士学位。

On December 3, 2025, three doctoral candidates, Lin Siming, Zhai Binbin, and Liu Xiangquan, from the Class 2025 cohort of the Physical Chemistry program at the Institute of New Concept Sensors and Molecular Materials of Shaanxi Normal University successfully defended their dissertations.

Their dissertation titles are: “Construction, Photophysical Properties, and Functional Applications of Porous Fluorescent Molecular Materials” “Controlled Construction of Flexible Functional Nanomembranes and Their Sensing Applications,” and “Interface-Confined Synthesis, Stimulus Responsiveness, and Applications of Organic Porous Films.”

The defense was chaired by Prof. Liu Feng from Xi’an Jiaotong University, while the defense committee members included Prof. Kong Jie from Northwestern Polytechnical University, Prof. Luan Xinjun from Northwest University, Prof. He Gang from Xi’an Jiaotong University, and Prof. Wu Weiwei from of Xidian University.



Following the presentations of their doctoral dissertations, the three doctoral candidates underwent questioning, evaluation, and commentary from the defense committee, who also provided suggestions for refining and revising their dissertations. After deliberation, the defense committee unanimously agreed that the research content of the three candidates' dissertations was thorough and logically sound, and that their responses to questions were clear, and they approved the defenses and recommended conferring them the Doctor of Science degree.

黄蓉蓉博士学位论文获评 2025 年陕西省优秀博士学位论文

Huang Rongrong's doctoral dissertation selected among 2025 Shaanxi Provincial Outstanding Doctoral Dissertations

据陕西省学位委员会、陕西省教育厅公示的2025年省级优秀博士学位论文评审结果，陕西师范大学新概念传感器与分子材料研究院2023届博士毕业生黄蓉蓉的博士学位论文《具有分子内电荷转移特性的邻碳硼烷衍生物设计合成、发光性质调控及应用》获评2025年陕西省优秀博士学位论文。

黄蓉蓉师从房喻院士，主要从事光物理技术及其在传感应用方面的研究，自2023年起先后在新加坡科技设计大学、南洋理工大学从事博士后研究。迄今已在Journal of the American Chemical Society、Angewandte Chemie International Edition、Chemical Society Reviews等国际学术期刊发表论文11篇。

According to the 2025 Provincial Outstanding Doctoral Dissertation Evaluation Results announced by the Shaanxi Provincial Academic Degrees Committee and the Shaanxi Provincial Department of Education, the doctoral dissertation titled "Design, Synthesis, Luminescent Property Regulation, and Application of Ortho-Carboborane Derivatives with Intramolecular Charge Transfer Characteristics" by Dr. Huang Rongrong, a Class 2023 doctoral graduate from the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University, has been selected as a 2025 Shaanxi Provincial Outstanding Doctoral Dissertation.

Huang Rongrong studied under Prof. Fang Yu, focusing on optical physics technology and its applications in sensing. Since 2023, she has conducted postdoctoral research at the Singapore University of Technology and Design and Nanyang Technological University. To date, she has published 11 papers in international academic journals including the Journal of the American Chemical Society, Angewandte Chemie International Edition, and Chemical Society Reviews.

房喻院士应邀继续担任英国皇家化学会“应用界面”期刊顾问委员会委员

Fang Yu continues to serve as member of Advisory Board for RSC Applied Interfaces

近日，房喻院士应英国皇家化学会期刊部邀请，继续担任“应用界面”（RSC Applied Interfaces）期刊顾问委员会委员，任期两年，至2027年底。

“应用界面”是英国皇家化学会于2023年创办的一本跨学科金色开放获取期刊，专注于应用表面与界面研究领域，聚焦界面科学在能源、材料、生物等领域的应用，涵盖电极－电解质界面动力学、纳米结构材料、光学诊断技术等前沿方向。

Recently, Prof. Fang Yu was invited by the Journals of the Royal Society of Chemistry to continue serving as a member of the Advisory Board for the journal Applied Interfaces for a two-year term till the end of 2027.

Applied Interfaces is a multidisciplinary gold open-access journal launched by the Royal Society of Chemistry in 2023. It focuses on applied surface and interface research, highlighting the application of interface science in energy, materials, and biological fields. The journal covers cutting-edge areas such as electrode-electrolyte interface dynamics, nanostructured materials, and optical diagnostic techniques.

薄鑫副研究员获聘《清洁能源科学与技术》青年编委

Bo Xin Appointed as a Youth Editorial Board Member of Clean Energy Science and Technology

Universe
Scientific Publishing

CERTIFICATE OF APPOINTMENT

AWARDED TO

Xin Bo

IN RECOGNITION OF THE APPOINTMENT AS

Youth Editorial Board Member of

Clean Energy Science and Technology

From January 2026 to December 2027

UNIVERSE SCIENTIFIC PUBLISHING.
December 2025

近日，陕西师范大学新概念传感器与分子材料研究院薄鑫副研究员被《清洁能源科学与技术》期刊聘任为青年编委，聘期为2026年1月至2027年12月。

Recently, Assoc. Prof. Bo Xin from the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University was appointed as a Young Editorial Board Member for the journal Clean Energy Science and Technology, with the appointment term running from January 2026 to December 2027.

陕师大新概念研究院教学范式入选2025年度虚拟教研室试点建设典型教研方法

SNNU INCSMM teaching paradigm selected as an exemplary teaching method for 2025 Virtual Teaching and Research Room Pilot Program

近日，在全国高等学校教学研究中心受教育部高等教育司委托组织开展的2025年度典型虚拟教研室、典型教研方法与典型教研成果“三个典型”评选中，由房喻院士担任负责人的国家级“西部高校化学专业（师范）虚拟教研室”报送的“以数育智、以产促教：化学专业学科自信与工程能力协同提升的教学范式”获评2025年度典型教研方法。

此教学范式的主要完成人为彭浩南、丁立平、刘太宏、罗艳彦和房喻。

Recently, in the 2025 “Three Exemplars” selection—covering exemplary virtual teaching and research rooms, exemplary teaching methodologies, and exemplary teaching achievements—organized by the National Center for Higher Education Teaching Research on behalf of the Department of Higher Education, Ministry of Education, the entry “Nurturing Intelligence Through Data, Enhancing Education Through Industry: A Teaching Paradigm for Synergistic Improvement of Disciplinary Confidence and Engineering Competence in Chemistry”, submitted by the national-level “Virtual Teaching and Research Room for Chemistry Programs (Teacher Education) in Western Universities” headed by Prof. Fang Yu, was honored as a 2025 Exemplary Teaching and Research Method.

The main contributors of the teaching paradigm are Peng Haonan, Ding Liping, Liu Taihong, Luo Yanyan, and Fang Yu.

房喻院士在第二届前沿交叉科学论坛暨西交大前沿院建院 15 周年大会上发表视频致辞

Fang Yu delivers video address at second Frontier Interdisciplinary Science Forum and 15th Anniversary Celebration of XJTU Frontier Institute

2025 年 12 月 20 日，第二届前沿交叉科学论坛暨西安交通大学前沿科学技术研究院建院 15 周年庆祝大会在中国西部科技创新港举行，房喻院士通过视频致辞表示，前沿院作为改革“特区”，在打破学科壁垒、创新交叉研究机制、支持青年学者独立发展等方面树立了典范，期待前沿院秉持初心、前瞻布局，在未来孕育出更多能够改变世界、服务国家的重要成果。

此次会议旨在庆祝前沿科学技术研究院建院 15 周年，汇聚校友及社会力量，搭建交叉学科高端平台，推动教育、科技、人才一体化建设，深入探讨创新策源与新质生产力，以融合创新驱动学科交叉与服务产业创新。中国工程院院士蒋庄德，中国科学院院士郭林，湖南大学副校长张晓兵，中国科学院西安光机所副所长付玉喜，西安交通大学党委常委、副校长柴渭等出席大会。来自全国各地 39 所高校及科研院所的负责人、专家学者，企业及社会团体代表及前沿院师生近 500 人参加了会议。

On December 20, 2025, at the Second Frontier Interdisciplinary Science Forum and the 15th Anniversary Celebration of Xi'an Jiaotong University's Frontier Institute of Science and Technology held at the China Western Innovation Port, Prof. Fang Yu delivered a video address, stating that as a special reform zone, the institute has set an exemplary standard in breaking down disciplinary barriers, innovating interdisciplinary research mechanisms, and supporting the independent development of young scholars, and he expressed his hope that the institute would remain true to its founding mission, adopt forward-looking strategies, and continue to foster significant achievements that can change the world and serve the nation.

This conference celebrates the 15th anniversary of the Frontier Institute of Science and Technology, and aims to bring together alumni and societal forces to establish a high-end platform for interdisciplinary research. It seeks to advance the integrated development of education, science and technology, and talent cultivation, while deeply exploring innovation-driven sources and new productive forces. Through integrated innovation, it will propel disciplinary convergence and serve industrial innovation. Attendees included Academician Jiang Zhuangde of the Chinese Academy of Engineering, Academician Guo Lin of the Chinese Academy of Sciences, vice president Zhang Xiaobing of Hunan University, deputy director Fu Yuxi of the Xi'an Institute of Optics and Precision Mechanics under the Chinese Academy of Sciences, and vice president Chai Wei of Xi'an Jiaotong University. Nearly 500 participants attended, including leaders, experts, and scholars from 39 universities and research institutions nationwide, representatives from enterprises and social organizations, as well as faculty and students from the Frontier Institute of Sciences and Technology.

房喻院士出席第十三届光功能材料与光电化学学术研讨会

Fang Yu attends 13th Symposium on Photofunctional Materials and Photoelectrochemistry

2025 年 12 月 21 日，房喻院士应邀赴福州市出席第十三届光功能材料与光电化学学术研讨会。此次研讨会由福州大学联合中国化学会分子光子学与激发态化学专业委员会主办，汇集海内外光功能材料与光电化学领域的专家学者，聚焦国际前沿动态，分享研究成果，深化学术合作，助力国内相关领域科研创新与产业升级。

On December 21, 2025, Prof. Fang Yu was invited to attend the 13th Symposium on Photofunctional Materials and Photoelectrochemistry in Fuzhou City. Co-hosted by Fuzhou University and the Committee on Molecular Photonics and Excited-State Chemistry of the Chinese Chemical Society, the symposium brought together experts and scholars from around the world in the related fields, who focused on cutting-edge international developments, shared research findings, deepened academic collaboration, so as to advance scientific innovation and industrial upgrading in related domestic sectors.

房喻院士获聘胶体与界面化学教育部重点实验室（山东大学）学术委员会副主任

Fang Yu appointed vice director of Academic Committee of Key Laboratory of Colloid and Interface Chemistry, Ministry of Education (Shandong University)

聘　书

兹聘请房喻先生担任胶体与界面化学教育部重点实验室（山东大学）第五届学术委员会副主任委员，任期五年(2025年至2029年)。

山东大学化学与化工学院
二〇二五年十二月

2025 年 12 月 21 日，房喻院士应邀赴济南市出席在山东大学召开的胶体与界面化学教育部重点实验室第五届学术委员会第一次全体会议，并获聘担任胶体与界面化学教育部重点实验室（山东大学）第五届学术委员会副主任委员，任期五年（2025 年至 2029 年）。

On December 21, 2025, Prof. Fang Yu was invited to attend the first plenary meeting of the Fifth Academic Committee of the Key Laboratory of Colloid and Interface Chemistry, Ministry of Education at Shandong University in Jinan, where he was appointed as vice director of the Fifth Academic Committee of the Key Laboratory of Colloid and Interface Chemistry, Ministry of Education (Shandong University) for a five-year term (2025–2029).

研究院代表出席陕西省光子科技实验室第一次理事单位会议

INCSMM representatives attend first council member meeting of Shaanxi Provincial Photonics Technology Laboratory

2025 年 12 月 22 日，陕西师范大学副校长陈新兵、科学技术处处长薛东作为共建单位代表，陕师大新概念传感器与分子材料研究院丁立平和马佳妮作为理事单位代表，出席了在西安举办的陕西省光子科技实验室建设推进会暨第一次理事单位会议。

陕西省光子科技实验室由中国科学院西安光学精密机械研究所作为理

事长单位和陕西光电子先导院科技有限公司作为依托单位联合发起组建，围绕先进阿秒激光设施大科学装置，打造“大科学装置 + 大创新平台 + 大基金体系 + 大科创生态”一体化高能级创新联合体，重点推进光子技术基础研究、应用基础研究、关键核心技术攻关及成果转移转化，打造光子领域战略科技力量，加速科技创新与产业创新深度融合。

On December 22, 2025, Chen Xinbing, vice president of Shaanxi Normal University, and Xue Dong, director of SNNU Science and Technology Division, as representatives of the co-construction units, and Ding Liping and Ma Jiani from SNNU Institute of New Concept Sensors and Molecular Materials, as representatives of the council member units, attended the Construction Promotion Meeting and the First Council Meeting of Shaanxi Provincial Photonics Technology Laboratory held in Xi’an.

Shaanxi Provincial Photonics Technology Laboratory was jointly established by the Xi’an Institute of Optics and Precision Mechanics of the Chinese Academy of Sciences as the chair unit and Shaanxi Optoelectronics Pioneer Institute Technology Co., Ltd. as the supporting unit. Operated around the advanced attosecond laser facility as a major scientific instrument, it aims to build an integrated high-level innovation consortium featuring “major scientific instruments + large-scale innovation platforms + large-scale funding systems + comprehensive innovation ecosystems.” It prioritizes advancing fundamental research in photonics, applied basic research, breakthroughs in core technologies, and the transfer and commercialization of research outcomes, cultivating strategic scientific capabilities in the photonics field and accelerating the integration of scientific innovation with industrial innovation.

房喻院士出席软物质界面化学研讨会

Fang Yu attends Soft Matter Interface Chemistry Symposium

2025 年 12 月 27 日，房喻院士出席了在广州市举办的“软物质界面化学研讨会”，主持了上午议题二“软物质界面化学的基础理论与表征方法”的集中研讨，并联合主持了下午“凝练关键科学问题和前沿领域方向”的综合研讨。

此次会议由国家自然科学基金委员会化学科学部主办，华南理工大学前沿软物质学院承办。陕西师范大学新概念传感器与分子材料研究院丁立平教授和彭浩南教授参加了会议。

On December 27, 2025, Prof. Fang Yu attended the “Soft Matter Interface Chemistry Symposium” held in Guangzhou, where he chaired the focused discussion session on “Fundamental Theories and Characterization Methods in Soft Matter Interface Chemistry” in the morning and co-chaired the comprehensive discussion session on “Identifying Key Scientific Questions and Frontier Research Directions” in the afternoon.

The symposium was hosted by the Chemistry Division of the National Natural Science Foundation of China and organized by the School of Emergent Soft Matter at South China University of Technology. Prof. Ding Liping and Prof. Peng Haonan from the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University attended the event.

房喻院士参加第二届国家教材委员会第三次全体会议

Fang Yu attends third plenary meeting of second National Textbook Committee

2025 年 12 月 29 日，房喻院士在北京参加由丁薛祥副总理主持的第二届国家教材委员会第三次全体会议。

On December 29, 2025, Prof. Fang Yu attended the third plenary meeting of the second National Textbook Committee chaired by vice premier Ding Xuexiang in Beijing.

Angewandte Chemie

GDCh Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Forschungsartikel | Full Access

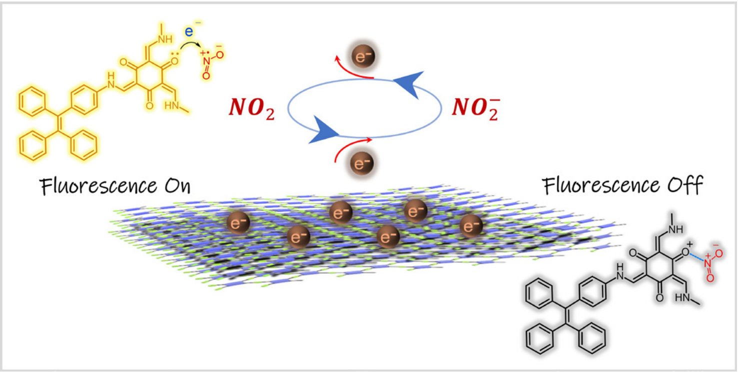
A 4+3 *β*-Ketoenamine-Linked Covalent Organic Framework Membrane for High-Performance Film-Based Fluorescent NO_2 Sensor

Xiangquan Liu, Zhicong Zhang, Lingya Peng, Jinglun Yang, Yan Jiang, Rongrong Huang, Yan Luo, Dongxu Xue, Sanyuan Ding, Daqiang Yuan, Xiaoyan Liu ✉, Liping Ding ✉, Yu Fang ✉

First published: 04 December 2025 | https://doi.org/10.1002/ange.202520736 |

4+3 β－酮烯胺键 COF 膜用于构建高性能 NO2 薄膜荧光传感器

Xiangquan Liu, Zhicong Zhang, Lingya Peng, Jinglun Yang, Yan Jiang, Rongrong Huang, Yan Luo, Dongxu Xue, Sanyuan Ding, Daqiang Yuan, Xiaoyan Liu, Liping Ding, Yu Fang. Angew. Chem. Int. Ed. 2025, e20736. DOI: 10.1002/anie.202520736



NO_2 会导致酸雨、雾霾、温室效应和人类呼吸道疾病率。目前，监测 NO_2 的方法仍以紫外可见吸收光谱法为主。尽管其灵敏度达标，但仪器成本高昂、操作复杂无法实现原位在线监测。因此，发展实时检测低浓度 NO_2 的新方法迫在眉睫。

近年来，结构简单、体积小且能快速现场检测 NO_2 的传感器研发已取得重要进展。例如，研究小组开发了能室温运行、灵敏度高的电化学传感器，但其依赖贵金属电极，制造成本高、长期稳定性不足。化学电阻式传感器具有成本低廉、制备简易等优点，但其面临选择性差与工作温度高等挑战。最近，MOF、COF 以及碳纳米管等多孔材料被应用于构建 NO_2 电阻式传感器，此类传感器在室温条件下展现出高灵敏度和选择性，然而，其响应恢复时间通常长达数十秒到数分钟。目前，开发结构简单、尺寸紧凑、能够快速检测 NO_2 的便携式传感器仍面临较大挑战。

薄膜荧光传感器因其高灵敏度、可设计性强、硬件结构相对简单以及选择性高等优势受到广泛关注。COF 是一类具有晶态多孔结构的有机材料，其特征包括高比表面积、可调孔径以及优异的孔隙率。其中，β－酮烯胺键 COF，其具有高度共轭的骨架、丰富的孔隙结构、富电子特性及优异的化学稳定性。界面聚合方法制备的 COF 薄膜有望促进传质并集成于传感器中。

近日，本团队通过四（4- 氨基苯基）乙烯（ETTA）和 1,3,5- 三甲酰基苯酚（TP）单体的界面限域缩合反应，制备了 β－酮烯胺连接的荧光共价有机骨架 (COF) 膜（图 1），并基于该材

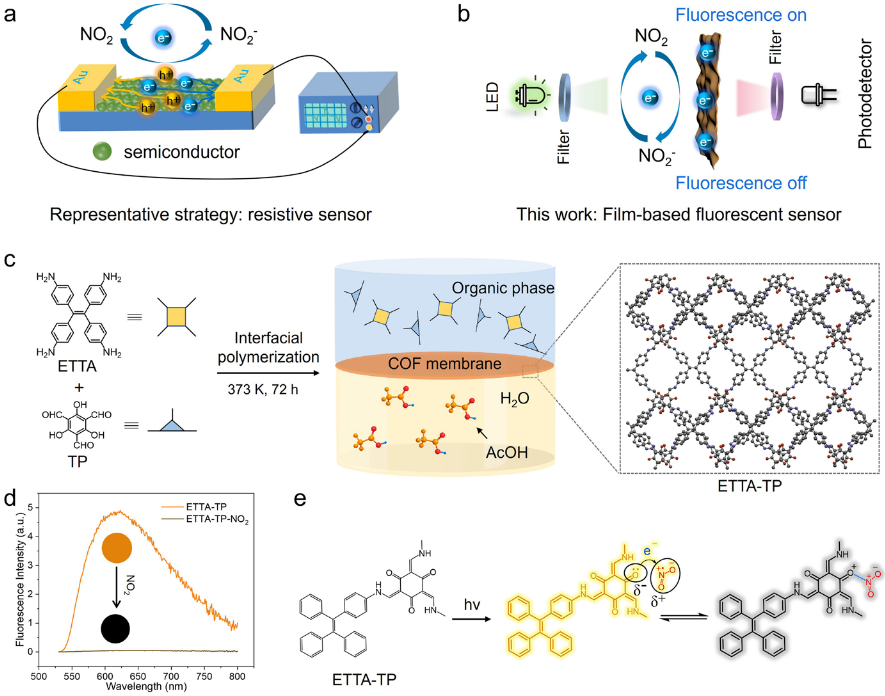


图 1. ETTA−TP COF 膜的制备及其对 NO2 响应

Figure 1. Schematic representation of the β-ketoenamine linked ETTA-TP COF membrane and its fluorescence response to NO$_2$.

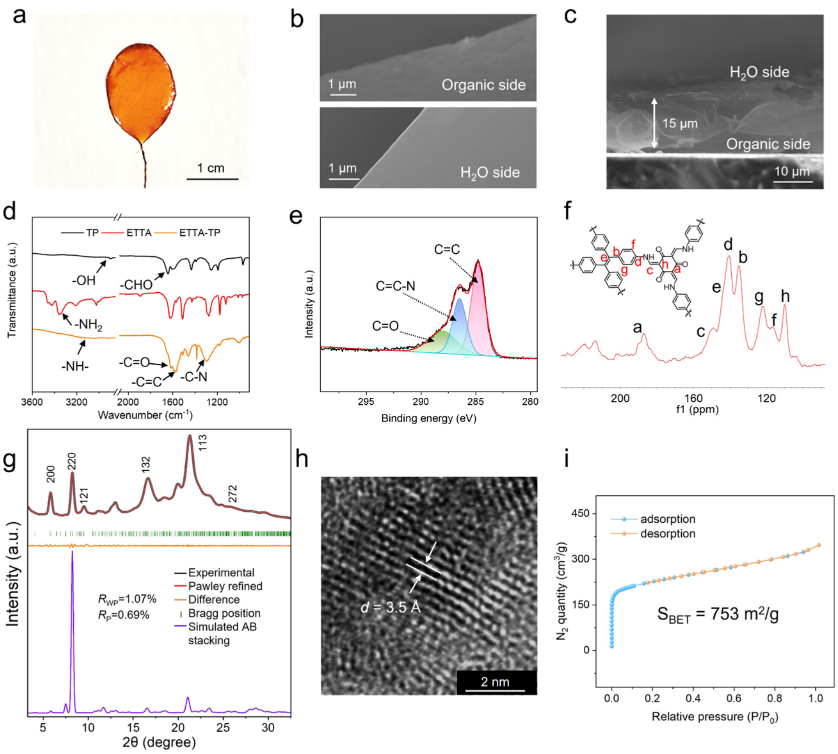


图 2. ETTA−TP COF 膜的照片、形貌和结构表征

Figure 2. Photograph and characterization of the ETTA-TP COF membrane.

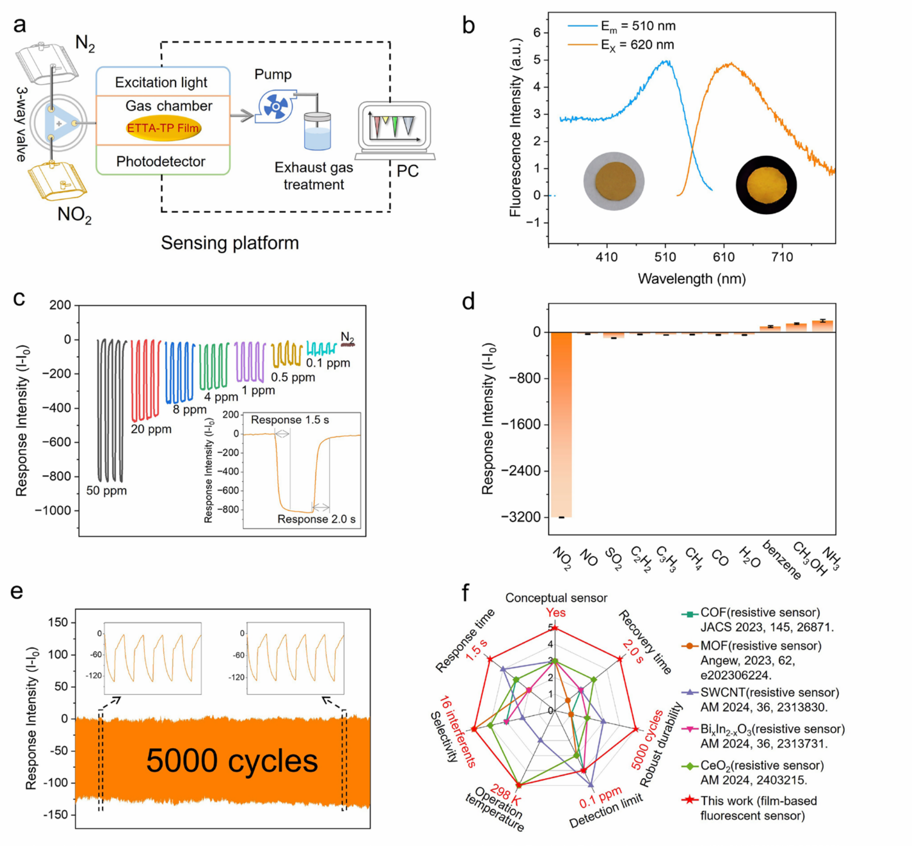


图 3. 荧光传感器的 NO_2 检测性能

Figure 3. NO_2 sensing performance of the ETTA-TP COF membrane.

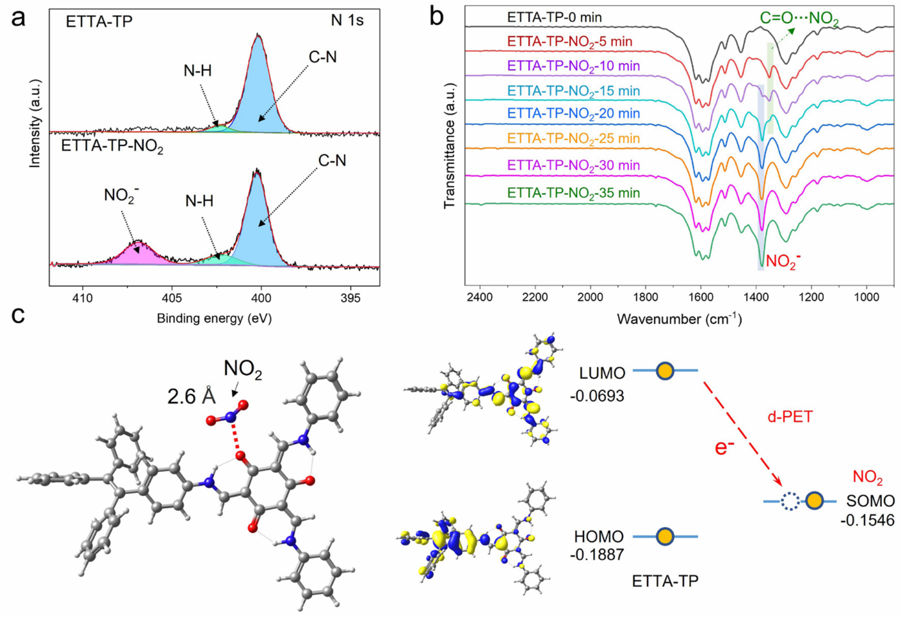


图 4. ETTA−TP COF 膜的 NO2 响应机理

Figure 4. Investigation of the fluorescence quenching mechanism of the ETTA-TP COF membrane to NO2.

料开发了性能优异的 NO2 薄膜荧光传感器。FTIR、XRD、SEM、TEM 等表征表明了该COF膜的成功制备（图2）。

基于该 COF 膜对 NO2 表现出可逆的荧光猝灭响应，构建了 NO2 薄膜荧光传感器（图3）。该传感器具有超快速响应 / 恢复速度 (1.5 s/2.0 s)，优异的选择性（可排除 16 种潜在干扰物）。此外，该传感器还具有较低的检出限（0.1 ppm）和较宽的检测范围（0.1–50 ppm），并在 5000 次连续测试中保持了良好的稳定性。此外，该传感器能够实现对汽车尾气与垃圾焚烧过程中产生的 NO2 进行原位在线监测，显示出良好的应用潜力。

传感器对 NO_2 优异的响应性能得益于 ETTA–TP COF 膜具有方形网格拓扑结构，其具有高度多孔结构以及较小的孔径，其比表面积高达 753 m^2/g，能促进传质及活性位点的充分利用，而其孔径约为 0.6 nm，可以通过限域效应促进气体分子与框架材料的传感过程。通过红外光谱，XPS 光谱，EPR 光谱测试和理论计算证明了 COF 膜与 NO_2 之间发生了光诱导电子转移过程（图4）。通过薄膜以及小分子对照实验证明了 NO_2 的结合位点在羰基，含有羰基的小分子以及 COF 材料对 NO_2 的荧光响应验证了该作用位点的普适性。理论计算表面羰基与 NO_2 之间的静电相互作用有效驱动了光诱导电子转移过程，进而引起显著的荧光猝灭响应。

本研究为发展具有快速响应、高灵敏度和原位在线监测能力的便携式气体传感器提供了新方法。

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Nitrogen dioxide (NO_2) is associated with acid rain, smog, greenhouse effects, and human respiratory diseases. Currently, NO_2 monitoring mainly relies on ultraviolet-visible absorption spectroscopy. While the method meets sensitivity requirements, the instruments are costly and huge, preventing in situ online monitoring. Consequently, there is an urgent need for new approaches that enable real-time detection of low NO_2 concentrations.

In recent years, sensors that are simple in structure, small in size, and capable of rapid on-site NO_2 detection have made significant progress. For example, some groups have developed room-temperature electrochemical sensors with high sensitivity, albeit relying on expensive noble metal electrodes, which raises manufacturing costs and compromises long-term stability. Chemoresistive sensors offer low cost and easy fabrication but suffer from poor selectivity and high operating temperatures. Recently, porous materials such as MOFs, COFs, and carbon nanotubes have been used to construct NO_2 resistive sensors, which show high sensitivity and selectivity at room temperature. However, their response recovery times typically span tens of seconds to minutes. Therefore, developing compact, structurally simple, portable sensors capable of rapidly detecting NO2 remains challenging.

Film-based fluorescence sensors have attracted broad attention due to their high sensitivity, design flexibility, relatively simple hardware, and high selectivity. COFs are crystalline porous organic materials characterized by high surface area, tunable pore sizes, and excellent porosity. β-ketoenamine-linked COFs, with highly conjugated backbones, rich porosity, electron-rich characteristics, and strong chemical stability, are particularly promising. Interfacial polymerization enables the fabrication of COF thin films conducive to mass transport and sensor integration.

Recently, our team prepared a β-ketoenamine-linked fluorescence covalent organic framework (COF) membrane via interfacial confined condensation reactions between 4-aminostyrene (ETTA) and trimesic aldehyde (TP) to form the ETTA-TP COF. The membrane was characterized by FTIR, XRD, SEM, and TEM, confirming successful synthesis. Based on its NO_2 responsive, reversible fluorescence quenching behavior, we developed a NO2 film-based fluorescence sensor. The sensor exhibits ultra-fast response/recovery times (1.5 s / 2.0 s), excellent selectivity (able to exclude 16 potential interferents), a low detection limit (0.1 ppm), and a wide detection range (0.1-50 ppm). It maintained good stability over 5,000 consecutive tests and enables in situ online monitoring of NO2 from automotive exhaust and incineration processes, highlighting strong application potential.

The superior NO_2 response arises from the square-grid topology of the ETTA-TP COF membrane, its high porosity with small pore size, and a surface area up to 753 m^2 g^{-1}; the pore size (~0.6 nm) facilitates gas molecule diffusion and interaction with active sites via confinement effects. Infrared, XPS, EPR, and theoretical calculations indicate a photoinduced electron transfer between NO_2 and the COF membrane. Control experiments with thin films and small molecules show that the carbonyl groups serve as universal NO_2 binding sites for the fluorescence response. Theoretical calculations suggest electrostatic interactions between surface carbonyls and NO_2 drive the photoinduced electron transfer that results in fluorescence quenching. This work provides a new approach for developing portable gas sensors with fast response, high sensitivity, and in situ online monitoring capability for NO_2.

This study develops a new method to the design of ultra-sensitive film-based fluorescent sensors (FFSs).

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analytical chemistry

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Deprotonated Nanofilms-Enabled Fluorescence-Colorimetric Dual-Mode Sensing of 3-Hydroxy-2-butanone

Xue Gu, Xinyu Gou, Yan Jiang, Xiangquan Liu, Binbin Zhai, Ruijuan Wen, Zhiyan Ma,* and Yu Fang*

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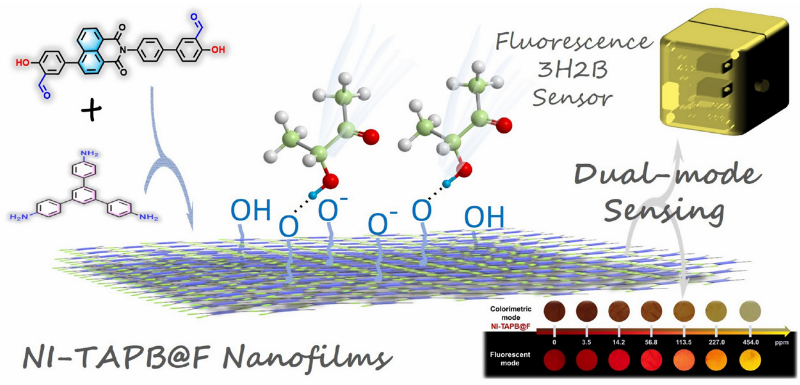
去质子化纳米薄膜用于 3– 羟基 –2– 丁酮的荧光 – 比色双模式传感

Xue Gu, Xinyu Gou, Yan Jiang, Xiangquan Liu, Binbin Zhai, Ruijuan Wen, Zhiyan Ma*, Yu Fang*. Anal. Chem. 2025, DOI: 10.1021/acs.analchem.5c04302



3– 羟基 –2– 丁酮（3H2B） 是单核细胞增生李斯特菌的关键气态代谢物、一种潜在的肺癌生物标志物，也是一种广泛使用的食品风味剂，因此对其进行实时监测的需求日益凸显。本研究设计了一种水杨醛功能化的 1,8– 萘酰亚胺衍生物（NI–OH–CHO），并将其与 1,3,5– 三（4– 氨基苯基）苯（TAPB）在液 / 液界面反应，制备了 NI–TAPB 荧光纳米薄膜。该薄膜经去质子化后（NI–TAPB@F），对 3H2B 表现出可逆且前所未有的荧光响应。

基于此发现，我们开发了一种性能卓越的荧光 3H2B 传感器，具备以下特点：在室温下具有超高灵敏度（检测限约 1.8 ppb）、快速响应（<8 s）、优异的选择性以及良好的稳定性。这些优势源于结合位点的理性设计与纳米薄膜的多孔结构。此外，利用去质子化薄膜实现了对 3H2B 的可视化检测。值得注意的是，该纳米薄膜具备自支撑、自粘附与柔性特性，能够消除背景颜色或发射的干扰，实现与基底无关的检测，并便于进行现场定性与定量分析。本研究有望为开发便携式 3H2B 检测设备开辟新途径。

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3-Hydroxy-2-butanone (3H2B) is a key gaseous metabolite of Listeria monocytogenes, a potential lung cancer biomarker, and a widely used food flavoring agent, underscoring the demand for real-time monitoring solutions. In this study, we designed a salicylaldehyde-functionalized 1,8-naphthalimide derivative (NI-OH-CHO) and reacted it with 1,3,5-tri(4-aminophenyl)benzene (TAPB) at a liquid/liquid interface to synthesize fluorescent NI-TAPB nanofilms.

Upon deprotonation, the nanofilms (NI-TAPB@F) exhibit a reversible and unprecedented fluorescence response to 3H2B. Leveraging this discovery, we developed a fluorescent 3H2B sensor with exceptional performance: ultrahigh sensitivity (detection limit: ～ 1.8 ppb), rapid response (<8 s), outstanding selectivity, and remarkable stability at room temperature. These advantages stem from the rational design of binding sites

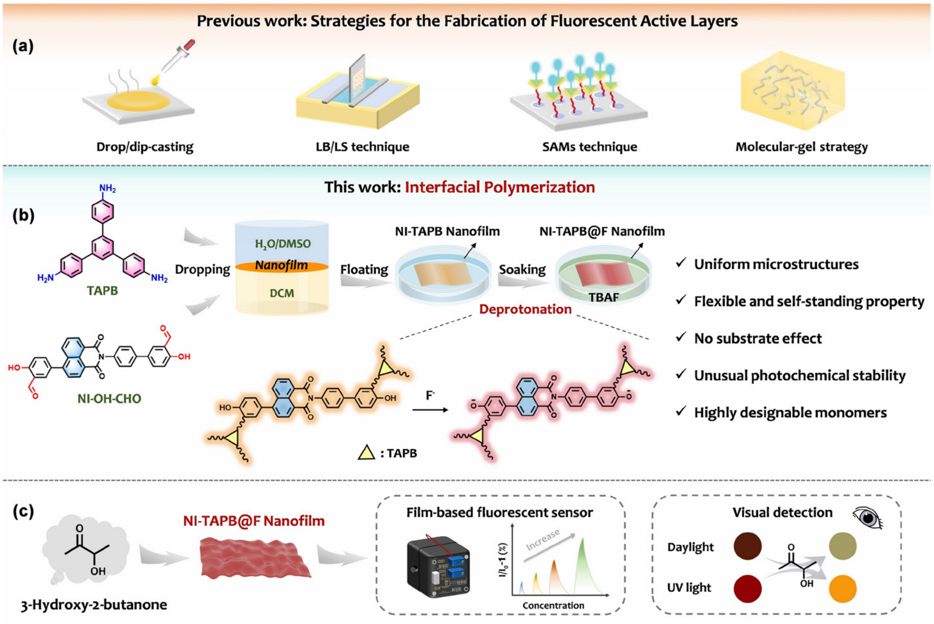

图 1. NI−TAPB 纳米薄膜的构建单元、界面聚合制备、去质子化机制示意图。

Figure 1. Schematic Molecular Structures of Building Blocks and Preparation Schematic of NI-TAPB Nanofilm through Interfacial Polymerization, with Subsequent Deprotonation Mechanism.

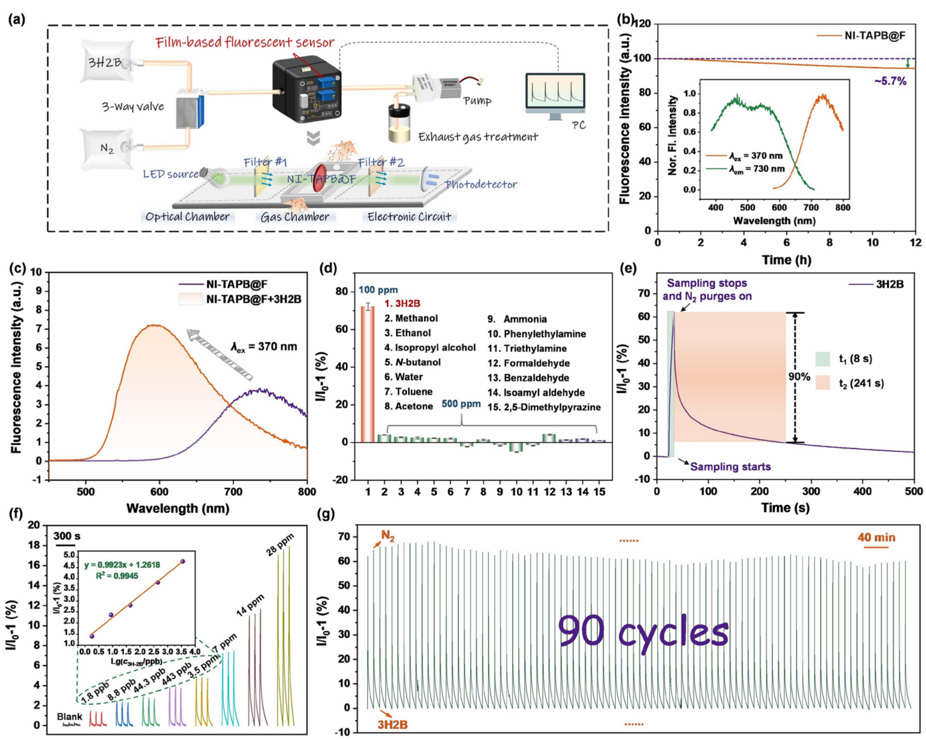

图 2. 荧光传感器的 3H2B 检测性能。

Figure 2. 3H2B Sensing Performance of the Fluorescent Sensor.

and the porous structure of the nanofilms.

Furthermore, visual 3H2B detection was achieved using the deprotonated films. Notably, the nanofilms are self-standing, self-adhesive, and flexible, enabling substrate-independent detection by eliminating interference from background color or emission. These properties also facilitate on-site qualitative and quantitative analysis. We anticipate this work will pave the way for the development of portable 3H2B detection devices.

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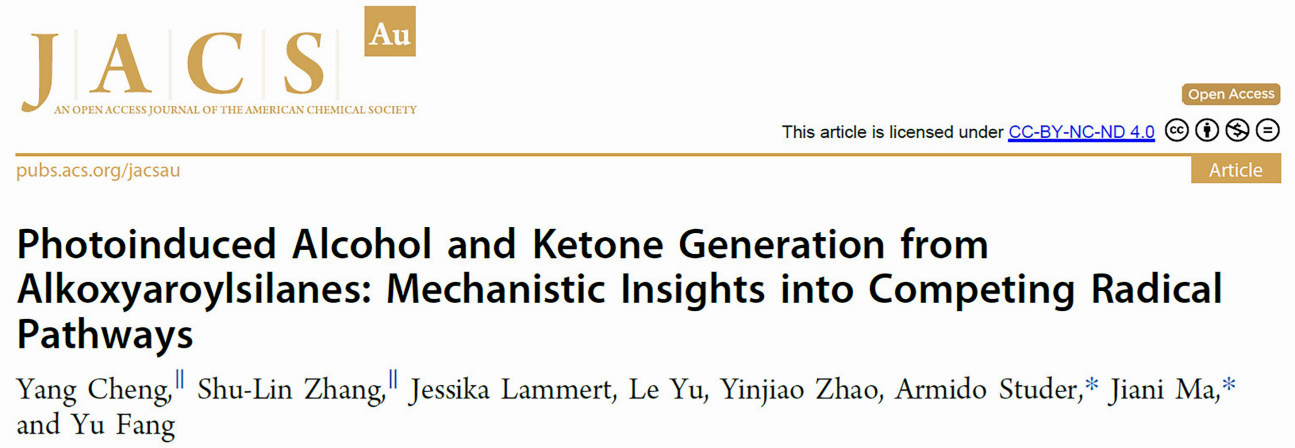

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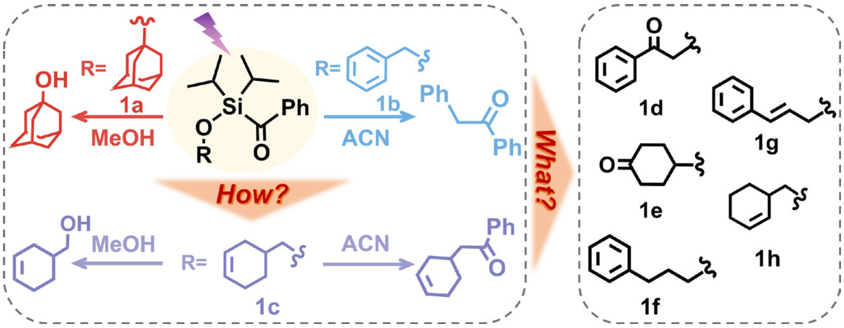
Article

Photoinduced Alcohol and Ketone Generation from Alkoxyaroylsilanes: Mechanistic Insights into Competing Radical Pathways

Yang Cheng,[‖] Shu-Lin Zhang,[‖] Jessika Lammert, Le Yu, Yinjiao Zhao, Armido Studer,* Jiani Ma,* and Yu Fang

光驱动烷氧基芳酰基硅烷生成醇与酮：揭示竞争性自由基通道的反应机制

Yang Cheng, Shu-Lin Zhang, Jessika Lammert, Le Yu, Yinjiao Zhao, Armido Studer,* Jiani Ma,* and Yu Fang. JACS Au, 2025, DOI: 10.1021/jacsau.5c01342



光敏保护基因其“光触发、可时空精准控制”的特点，在药物递送、光控合成、光遗传学等领域具有广泛应用。传统基于碳酸酯的光保护策略存在合成繁琐、光解后仍需热脱羧、时空控制精度有限等问题。苯甲酰二异丙基硅烷（BDIPS）作为新型可见光响应的硅基 PPG，然而研究人员发现，不同结构的 BDIPS 醚在光照后得到不同的产物：部分分子可顺利释放醇，但含苄基或烯丙基结构的 BDIPS 醚却只能生成酮衍生物。该现象缺乏统一的机制解释，制约了 BDIPS 的进一步应用。

针对这一问题，本研究通过结合飞秒瞬态吸收光谱与密度泛函理论计算，深入探究了三种模型化合物（1a、1b、1c）的光反应路径。研究表明，对于不含活化 α–H 的 BDIPS 醚，如 1a 和 1c–1f（图 1），光激发后最优反应路径是 1,2– 硅迁移。该路径几乎无势垒即可发生，可迅速生成高度活泼的硅氧卡宾中间体。随后卡宾会与溶剂甲醇的 O–H 键发生插入反应，随后高效实现醇的脱保护。对于含有苄基或烯丙基等具有活化 α–H 结构的 BDIPS 醚（如 1b、1g 和 1h，图 1），研究显示其主要经历 1,5– 氢原子转移（1,5–HAT）。α–H 的存在显著降低 HAT 能垒，使其竞争优势明显。一旦形成双自由基中间体，体系将进一步经历环化、质子化与开环，最终生成稳定的重排酮。

最具代表性的重要发现为 1c 的反应机制研究，该分子在甲醇中生成醇，而在乙腈中的产物为酮衍生物。势能面分析表明，1c 的硅迁移与氢转移能垒接近，是典型的“双通道竞争体系”。甲醇具有良好的给氢能力与氢键作用，从而加速卡宾插入，使硅转移反应成为优势通道；而乙腈难以为卡宾提供稳定环境，使 HAT 路径更易进行，因此生成酮为主要路径。该结果从根本上揭示了溶剂在光控反应路径选择中的调控机制。

该研究不仅阐明了 BDIPS 光化学反应机制，更提出了基于“结构–溶剂协同调控”的全新设计理念。在

光激发条件保持不变的情况下，通过精准调整分子结构与溶剂环境，即可精准调控硅迁移与氢转移两条路径，从而选择性地生成醇或酮产物。这一发现将光化学反应从常见的“被动结果”转变为可根据需求进行调控，为光控药物递送、智能响应材料、光驱动聚合等领域的分子设计提供了重要理论基础与实践指导。

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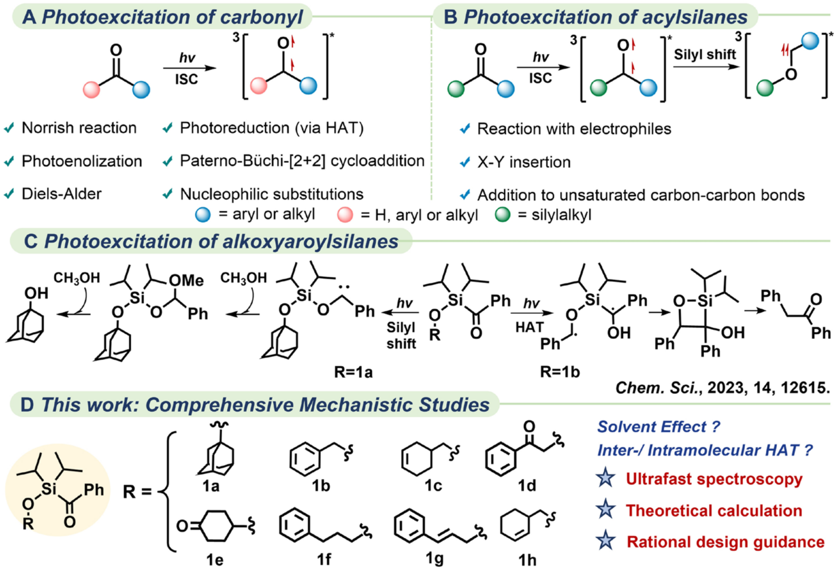

图 1. (A) 羰基化合物、(B) 酰基硅烷、(C) 烷氧基芳基硅烷的光化学反应示例，以及 (D) 本研究示意图
Figure 1. Reactivity overview of photoexcited species of (A) carbonyl compounds, (B) acylsilanes, (C) alkoxyaroylsilanes and (D) The schematic outline of this work.

Photolabile protecting groups (PPGs), featuring light-triggered and spatiotemporally precise activation, have found broad applications in drug delivery, light-controlled synthesis, optogenetics, and related fields. Traditional carbonate-based photocaging strategies, however, suffer from laborious synthesis, the need for thermal decarboxylation after photolysis, and limited spatiotemporal precision. Benzoyl diisopropyl silane (BDIPS) has emerged as a new class of silicon-based, visible-light-responsive PPGs. Yet researchers have observed that BDIPS ethers with different structures yield distinct photoproducts: while some molecules successfully release alcohols, BDIPS ethers containing benzylic or allylic moieties exclusively produce ketone derivatives. This phenomenon lacks a unified mechanistic explanation, which has hindered the broader application of BDIPS.

To address this challenge, the present study combines femtosecond transient absorption (fs-TA) spectroscopy with density functional theory (DFT) calculations to elucidate the photoreaction pathways of three model compounds (1a, 1b, and 1c). The results reveal that BDIPS ethers lacking activated α-hydrogens—such as 1a and 1c–1f (Figure 1)—favor a 1,2-silyl shift upon photoexcitation. This pathway proceeds with an almost negligible barrier, rapidly forming a highly reactive siloxycarbene intermediate, which subsequently undergoes O–H insertion with methanol, efficiently leading to alcohol deprotection. In contrast, BDIPS ethers containing activated α-hydrogens—such as benzylic or allylic groups (e.g., 1b, 1g, and 1h, Figure 1)—predominantly undergo 1,5-hydrogen atom transfer (1,5-HAT). The presence of α-H significantly lowers the HAT barrier, giving this pathway a clear kinetic advantage. Once a biradical intermediate is formed, it undergoes cyclization, protonation, and ring opening to yield a stable rearranged ketone.

A particularly representative discovery concerns the reaction mechanism of 1c, which forms an alcohol in methanol but yields a ketone derivative in acetonitrile. Potential energy surface analysis shows that the energy barriers for silyl migration and HAT are comparable in 1c, making it a prototypical “dual-pathway competitive system.” Methanol, with strong hydrogen-donating capability and hydrogen-bonding interactions, accelerates carbene insertion, rendering the silyl-shift pathway dominant. In contrast, acetonitrile provides a less stabilizing environment for the carbene, allowing the HAT pathway to prevail, thus favoring ketone formation. These findings fundamentally reveal how solvent environments regulate photochemical pathway selection.

Overall, this study fully elucidates the photochemical mechanism of BDIPS-based PPGs and introduces a new design principle based on structure–solvent cooperative control. Under identical photoexcitation conditions, selective formation of alcohol or ketone products can be achieved simply by tuning molecular structure and solvent environment. This insight shifts photochemical outcomes from passive consequences to actively programmable processes, offering valuable theoretical and practical guidance for applications in photocontrolled drug delivery, stimuli-responsive materials, and light-driven polymerization.

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Deciphering Carbene Reactivity: Ultrafast Spectroscopy and Computational Insights into Photochemical Heterocycle Formation

Yinjiao Zhao,† Yang Cheng,† Shu-Lin Zhang, Le Yu, David Lee Phillips, Jiani Ma,* and Yu Fang

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解析卡宾反应活性：超快光谱学与理论计算阐明光驱动生成杂环化合物

Yinjiao Zhao,† Yang Cheng,† Shu-Lin Zhang, Le Yu,, David Lee Phillips, Jiani Ma*, and Yu Fang. J. Phys. Chem. Lett. 2025 DOI: https://doi.org/10.1021/acs.jpclett.5c03347

杂环化合物的高效合成是药物创制与先进功能材料研发领域中的核心驱动力。近年来，光诱导卡宾反应作为一种温和、无需催化剂的绿色合成途径，为构建复杂杂环体系提供了高效方法。其中，以重氮化合物（诸如α－重氮酯、α－重氮酮）与酰基硅烷为代表的光敏前体，可在可见光激发下实现重排与环化反应。

以重氮化合物C1为例，其反应路径可通过溶剂环境实现精准调控：在乙腈、甲苯或DMF等极性或芳烃溶剂中，该化合物能高效转化为苯并五元杂环；然而在乙醇溶剂中，仅观测到痕量产物。对酰基硅烷的研究发现分子结构对产物的选择性：烯烃官能化酰基硅烷（C2）在可见光下发生分子内[2+1]环加成，高效构建环丙烷骨架；而碳链缩短的类似物C3，产物为烯醇硅醚衍生的吡喃类化合物。

尽管如此，其背后的深层机理仍不清楚：溶剂如何精细调控卡宾的电子激发态、侧链长度的微妙变化如何支配环化路径的选择、以及关键中间体的动态演变行为等核心问题，仍有待系统研究。

马佳妮教授课题组选取C1、C2、C3作为模型体系，结合飞秒瞬态吸收光谱与密度泛函理论计算，系统揭示了溶剂与化学结构因素对卡宾光反应性的调控机制。

研究发现，溶剂能够有效调控卡宾自旋态：C1在极性非质子性溶剂中倾向于形成三重态卡宾发生Stevens重排；而在质子性溶剂中，体系更易经过单重态路径导向Wolff重排。这一发现明确了溶剂通过影响卡宾自旋态来切换反应渠道的物理机制。与此同时，侧链长度也被证实可决定反应命运：C2凭借其较长侧链得以发生环加成反应，而侧链较短的C3则因空间限制倾向发生retro–Michael/Michael级联反应，这揭示了侧链长度可通过调控关键中间体的稳定性来引导反应走向不同的环化模式。

基于上述结果，提出了一个普适性原则：卡宾反应性并非仅由前体结构决定，而是可通过溶剂化效应与取代基效应的协同作用进行精细调控。通过建立激发态动力学、卡宾自旋态与产物选择性之间的直接关联，本工作为发展绿色、无催化剂的光驱动环化策略提供了机理蓝图，有望推动针对特定杂环骨架的精准合成方法的设计。

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The efficient synthesis of heterocyclic compounds is crucial for the development of pharmaceuticals and functional materials. In recent years, photoir¬duced carbene reactions have emerged as a mild, catalyst-free, and green synthetic pathway, providing efficient methods for constructing complex heterocyclic systems. Among them, diazo compounds (e.g., α-diazo esters, α-diazo ketones) and acylsilanes, as two important

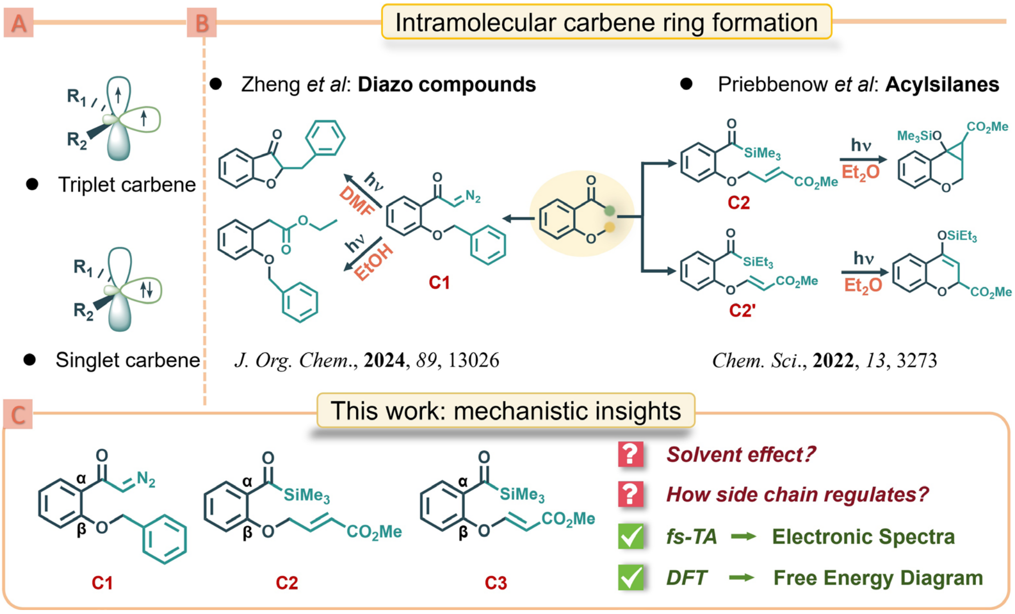

图 1. A：单线态和三线态卡宾分子结构示意图。B：重氮化合物和酰基硅烷的光化学反应。C：我们使用 fs–TA 光谱结合 DFT 来揭示 C1、C2 和 C3 的光化学反应机制。

Figure 1. (A) Two types of carbene. (B) Photochemical reactions of the diazo compound and acylsilanes. (C) Our work uses fs-TA spectroscopy combined with DFT to unravel the photochemical reaction mechanisms of C1, C2, and C3.

types of photoactive precursors, have attracted considerable attention due to their ability to undergo rearrangement and cyclization under visible light.

Taking the diazo compound C1 as an example, its reaction pathway can be precisely controlled by the solvent: it efficiently converts into benzofused five-membered heterocycles in solvents such as acetonitrile, toluene, or DMF, while only trace amounts of products are observed in ethanol. Similar selectivity has been observed in studies on acyl silanes. For instance, olefin-functionalized acyl silane C2 undergoes intramolecular [2+1] cycloaddition under visible light to efficiently construct cyclopropane frameworks, whereas its carbon-chain-shortened analog C3 tends to yield pyran derivatives derived from silyl enol ethers. The underlying mechanisms remain to be fully elucidated, such as how solvents affect the electronic states of carbenes, how side-chain length determines the cyclization mode, and the dynamic behavior of key intermediates.

To address these questions, the research team selected C1, C2, and C3 as model systems and combined femtosecond transient absorption spectroscopy with density functional theory calculations to systematically uncover the regulatory roles of solvent and chemical structure on carbene photoreactivity. The study reveals that solvents can effectively modulate carbene spin states: C1 tends to form triplet carbenes that undergo Stevens rearrangement in polar aprotic solvents, while in protic solvents, the system favors a singlet pathway leading to Wolff rearrangement. This finding clarifies the physical mechanism by which solvents switch reaction channels through influencing carbene spin states. At the same time, side-chain length was confirmed to determine reaction outcomes: C2, with its longer side chain, undergoes cycloaddition, whereas the shorter side chain of C3, due to spatial constraints, promotes a retro-Michael/Michael cascade reaction. This reveals that side-chain length can steer reactions toward different cyclization modes by modulating the stability of key intermediates.

Based on these results, a general principle is proposed: carbene reactivity is not solely determined by precursor structure but can be finely tuned through the synergistic effects of solvation and substituents. By establishing a direct correlation among excited-state dynamics, carbene spin states, and product selectivity, this work provides a mechanistic blueprint for developing green, catalyst-free, photo-driven cyclization strategies, which holds promise for advancing the design of precise synthetic methods targeting specific heterocyclic frameworks.

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pH and temperature dual-responsive Pickering emulsion stabilized by alginate-based microgel particles for encapsulation of curcumin

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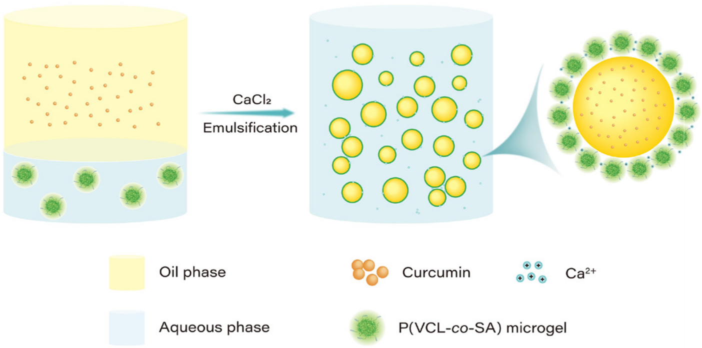
多重响应微凝胶颗粒稳定 Pickering 乳液及实现姜黄素高效封装

Yao Fu, Shuwen Tan, Xiaojia Xu, Wenlong Xing, Qi He, Yi Lu, Jia Tang, Xiaoyan Liu*, Yu Fang. Carbohydr. Polym. Technol. Appl. 2025, DOI: https://doi.org/10.1016/j.carpta.2025.101037



乳液广泛应用于食品、制药和农业等领域。通常采用表面活性剂稳定乳液，但这些化合物存在潜在毒性等问题，对水资源、生态系统和人类健康构成威胁。利用纳米颗粒作为稳定剂制备的 Pickering 乳液因其优异的界面稳定性和环境友好性受到广泛关注。

本工作成功制备了 pH 与温度双响应的海藻酸钠基微凝胶，并将其作为稳定剂制备了高性能 Pickering 乳液，显著提升了姜黄素的封装效率与保留率。采用简便高效的沉淀聚合法，将温度响应型单体 N- 乙烯基己内酰胺 (VCL) 与天然多糖海藻酸钠 (SA) 结合，构建了具有网络结构的 P(VCL–co–SA) 智能微凝胶颗粒。相较于微流控、乳液模版法等传统方式，该策略不仅操作简易、可规模化生产，还能获得尺寸均一、性能稳定的微凝胶颗粒。研究发现，该微凝胶在十二烷 / 水界面表现出优异的界面活性（图 1）。

该乳液在 25 ° C 下稳定水包油型 Pickering 乳液，并在 pH 3–9 范围内保持稳定。当温度升高至 55 ° C 时，乳液在 pH 6 与 pH 9（高于海藻酸盐 pKa ≈ 3.5）条件下仍保持稳定，仅在 pH 3 时出现相分离；同时，通过优化 Ca2+ 浓度，乳液的稳定性得到进一步增强。尤其是，由 P(VCL83–co–SA17) 微凝胶稳定的高内相大豆油 / 水乳液对姜黄素的包封效率接近 100 %，在室温下为其提供卓越保护。在 37 ° C 条件下储存 24 小时后，适量 Ca2+ 的加入显著提升了姜黄素的保留率：在 pH 3 中由 44.9 % 提升至 54.7 %，在 pH 7 中由 62.5 % 提升至 76.8 %（图 2）。

该乳液体系在生物活性化合物递送方面具有重要的应用潜力，为食品与医药领域构建更安全、更高效的载体系统提供了新思路。

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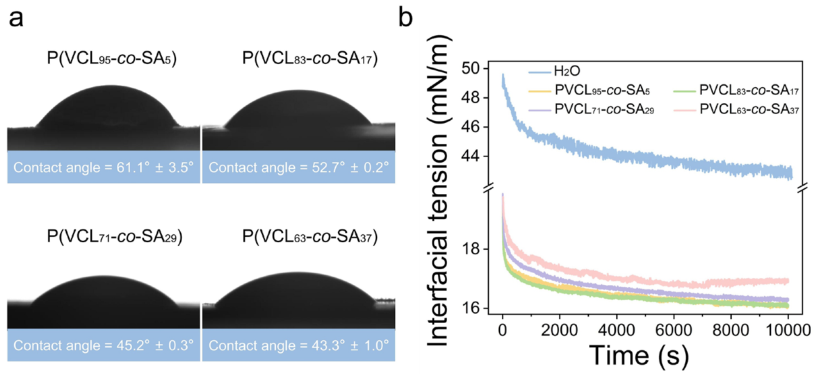

图 1. 微凝胶颗粒的水接触角及界面张力

Figure 1. Water contact angle and interfacial tension of the microgel film

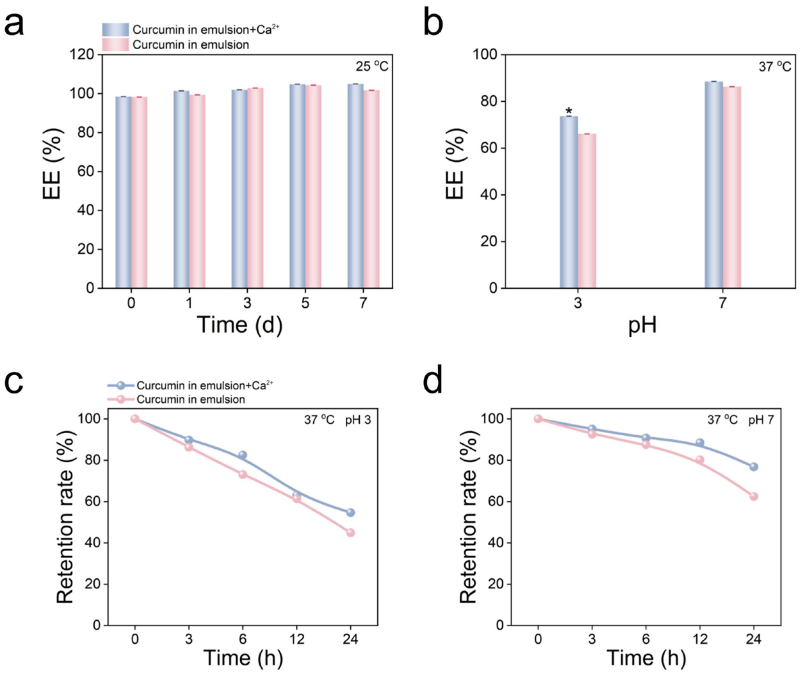

图 2. 大豆油 / 水乳液中姜黄素的包封效率和保留率

Figure 2. Encapsulation efficiency (EE) and retention rate of curcumin in soybean oil-in-water emulsions stabilized by the microgels

Emulsions are widely used in different fields, such as food, the pharmaceutical industry, and agriculture. Conventionally, emulsions are stabilized by surfactants; however, these compounds pose risks to water resources, environmental ecosystems, and human health due to their persistence and potential toxicity. Pickering emulsions have attracted extensive attention owing to their excellent interfacial stability and eco-friendliness. However, achieving precise control over their structures and imparting intelligent responsiveness still represents a major challenge in the contemporary field of functional materials.

To address these challenges, we, for the first time, prepared pH and temperature dual-responsive P(VCL-co-SA) microgels via free-radical precipitation polymerization method. Compared with other methods such as microfluidics and emulsion templating, the present polymerization approach is relatively simple and yields alginate-based microgels with uniform size. The obtained P(VCL-co-SA) microgels demonstrated high interfacial activity at the dodecane/water interface, enabling the stabilization of dodecane-in-water emulsions across a broad pH range (3–9) at 25 °C. At an elevated temperature (55 °C), the emulsions remained stable at pH 6 and 9 (above the pKa of alginate, ~3.5), while phase separation was observed at pH 3 below the pKa.

The emulsion stability was further enhanced by optimizing Ca2+ ion concentration. Furthermore, the high internal phase soybean oil-in-water emulsion stabilized by P(VCL83-co-SA17) microgels exhibited a curcumin encapsulation efficiency of nearly 100% and provided excellent protection at room temperature. When incubated at 37 °C for 24 hours, curcumin retention was significantly enhanced after the addition of Ca2+ ions, increasing it from 44.9% to 54.7% at pH 3 and from 62.5% to 76.8% at pH 7.

These findings demonstrate the considerable potential of this emulsion system for delivering bioactive compounds, paving the way for developing safer and more efficient carrier systems in the food and pharmaceutical industries.

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Full Length Article

Engineered three-dimensional Ti-based nanoarchitectures for enhanced photocatalytic uranium extraction from seawater

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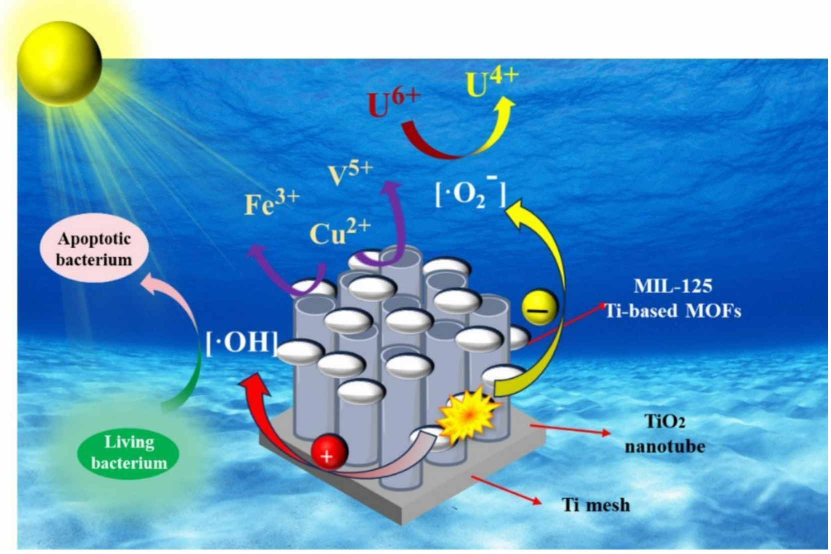
工程化三维钛基纳米结构及增强光催化海水提铀应用

Feng Zhou,* Yizhi Zeng, Chen Xie, Taihong Liu,* and Dingming Xue. Appl. Surface Sci. 2026, 723, 165616. DOI: https://doi.org/10.1016/j.apsusc.2025.165616



铀资源是核电可持续发展的基础。鉴于陆地铀矿相对稀缺，从储量丰富的海水中提取铀已成为一种绿色、可持续且前景广阔的替代方案。光催化铀提取技术因其快速提取动力学与固有的防污能力受到广泛关注，钛基材料因其对铀的强亲和性、高稳定性及低成本成为极具吸引力的候选材料。本工作报道了一种在钛网上原位构建的由二氧化钛纳米管与 MIL–125 钛基金属有机框架复合结构，从而形成三维钛基异质界面。这种层级结构显著扩大了有效催化界面，促进了界面电荷分离与传输，并优化了活性物种的生成与利用，共同实现了光催化铀提取性能的协同提升。所得材料在海水中表现出优异性能，光催化铀提取量达 312 mg · g–1，同时具备出色的循环稳定性。经过 10 次循环后仍保持 90% 的提取效率，并对微生物污染、有机污染物及竞争性吸附离子展现出强耐受性。本工作为海水提铀高效光催化剂的结构设计与性能优化提供了机理认知与研究借鉴。

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Uranium resources underpin the sustainable development of nuclear power. Given the relative scarcity of terrestrial uranium ores, extracting uranium from seawater, an abundant reservoir, has emerged as a green, sustainable, and promising alternative. Among various strategies, photocatalytic uranium extraction has attracted considerable attention owing to its rapid extraction kinetics and intrinsic antifouling capability. Within this context, Ti-based materials are particularly compelling candidates due to their strong affinity for uranium, high stability, and low cost. Herein, we report an in-situ construction of a composite architecture on Ti mesh, comprising TiO2 nanotubes and the MIL-125 titanium metal–organic framework, thereby forming a three-dimensional Ti-based heterointerface. This hierarchical configuration markedly enlarges the effective catalytic interface, facilitates interfacial charge separation and transport, and optimizes the generation and utilization of reactive species, collectively delivering synergistic enhancement in photocatalytic uranium extraction. The resulting material exhibits excellent performance in seawater matrices, achieving a photocatalytic uranium extraction amount of 312 mg·g-1. It also demonstrates outstanding recyclability, retaining over 90% of its uranium-extraction efficiency after 10 cycles, and displays robust tolerance to microbial fouling, organic contaminants, and competing adsorptive ions. This work offers mechanistic insights and a practical blueprint for the structural design and performance optimization of high-efficiency photocatalysts for seawater uranium extraction.

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席夫碱型四苯乙烯类薄膜荧光传感器阵列及其对神经性毒剂的区分检测

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席夫碱型四苯乙烯类薄膜荧光传感器阵列及其对神经性毒剂的区分检测

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化学传感器精确感知技术开发及便携式侦检装备研制对于毒剂的快速灵敏侦测和应急处置具有重要意义。本研究合成优选了两种席夫碱型四苯乙烯类荧光敏感物质 TCNB 和 TPE–33–BD，系统考察了其光物理特性，综合评估了其对神经性毒剂模拟物的传感性能。结果表明，TCNB 和 TPE–33–BD 薄膜荧光传感器对神经性毒剂模拟物氯磷酸二乙酯（DCP）的理论检出限分别低至 1.06 mg/m3 和 0.47 mg/m3。基于上述两种荧光敏感物质产生的交互荧光响应，构建了小型化薄膜荧光传感器阵列，实现了对 DCP 气体的灵敏、快速及选择性检测。该传感器阵列对 DCP 气体的响应时间小于 1.0 s，可重复使用次数大于 50 次。基于动态时域信号采集和交互响应信号

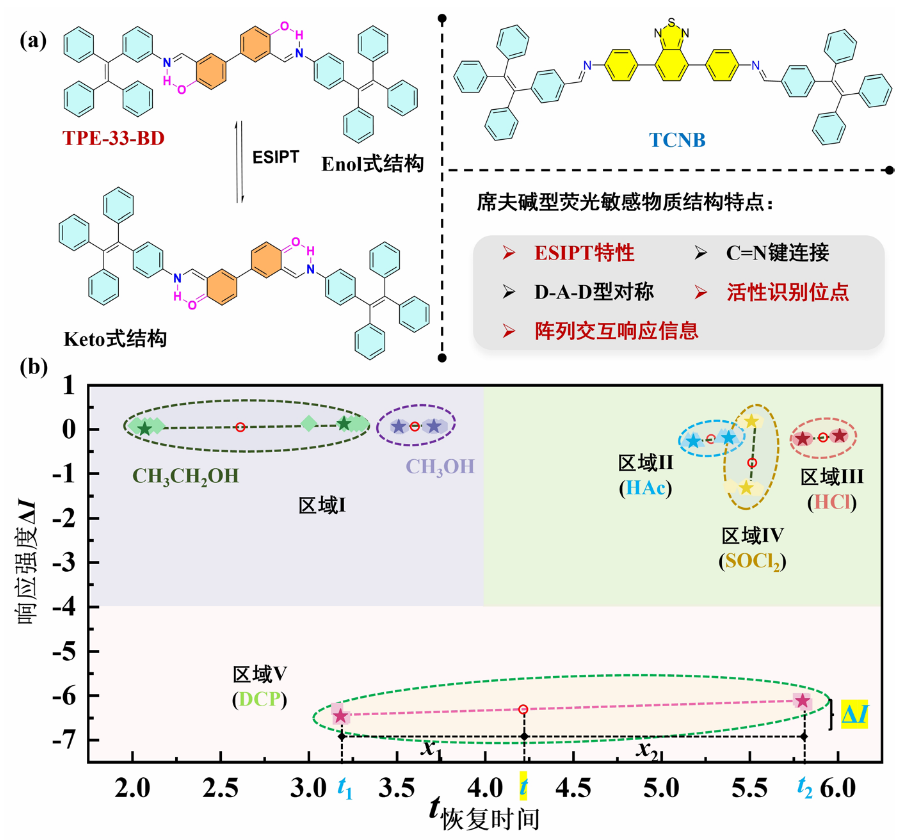

图 1. (a) 荧光敏感物质 TPE-33-BD 和 TCNB 的分子结构及其光学特性 ; (b) 二元薄膜荧光传感器阵列对 DCP、HCl、HAc 等的区分识别效果

Figure 1. (a) Molecular structures and optical characteristics of the fluorophores TPE-33-BD and TCNB; (b) Discrimination performance of binary thin-film fluorescence sensor arrays for DCP, HCl, HAc, etc.

处理，显著提升了该类薄膜荧光传感器阵列对神经性毒剂气体的精确感知和智能区分能力，可为新一代便携式毒剂侦检装备研制提供技术参考。

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Precise detection capabilities of chemical sensors and development of portable detection equipment are of great significance for the rapid detection and emergency response to nerve agents. Herein, two Schiff base-type fluorophores, TCNB and TPE-33-BD based on tetraphenylethylene, were synthesized and optimized properly. Their photophysical properties were systematically examined, and sensing capabilities for nerve agent simulants were comprehensively evaluated. The results indicated that the theoretical detection limits of the TCNB and TPE-33-BD for the nerve agent simulant diethyl chlorophosphate (DCP) were as low as 1.06 mg/m³ and 0.47 mg/m³, respectively. With the merits of high sensitivity, cross-reactive responses and easy miniaturization, a film-based fluorescent sensor array was constructed, which achieved sensitive, rapid, and selective detection of DCP vapor with a response time of less than 1.0 second and over 50 reusability cycles. Moreover, through dynamic data acquisition and cross-reactive signal processing, the accuracy and discrimination ability of the sensor array were significantly enhanced. The study could provide references for developing portable chemical agent detection equipment.

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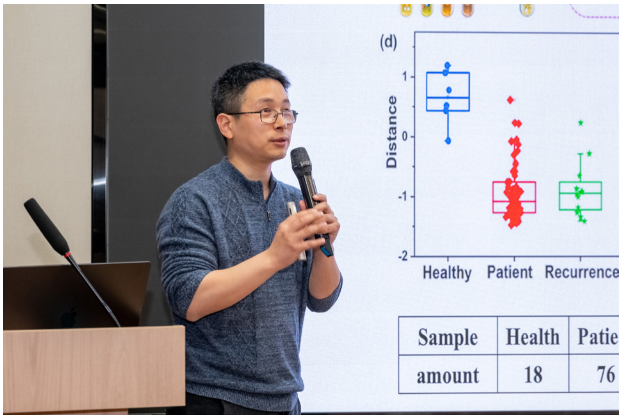
西工大孔杰教授和西电吴巍炜教授应邀作报告

NPU Prof. Kong Jie and Xidian Prof. Wu Wei Wei invited to give reports



2025 年 11 月 5 日下午，南京工业大学化工学院杨栋教授受邀访问陕西师范大学新概念传感器与分子材料研究院，并作题为“MOF 金属氧化物团簇节点的催化作用”的学术报告。

杨栋教授的研究探索金属有机框架（MOF）材料的稳定性、催化活性与其金属节点结构和配位环境之间的关联性。通过对锆基、铝基 MOF 的分析，发现表面羟基与甲酸根可有效表征金属位点反应性，甲醇脱水制二甲醚反应验证了其催化性能。节点羟基类型影响反应活性，甲酸根配位模式可区分孤立 / 成对节点。该研究明确了 MOF 活性位点的化学本质，为设计与优化多孔催化材料提供了重要依据。

报告会由边红涛教授课题组博士研究生马欣欢主持，薛东旭教授及 30 多名研究生参加了此次报告会。

On December 3, 2025, Prof. Kong Jie from Northwestern Polytechnical University and Prof. Wu Weiwei from Xidian University were invited to visit the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University, and give reports titled “Polymer-Converted Absorbing Materials: From Precursors to Metamaterials” and “DDisease Volatilomics and Electronic Nose Diagnostics” respectively.

Prof. Kong Jie presented the latest research findings on polymer-based absorptive materials, covering material design, synthesis, and their applications in electromagnetic wave absorption. He emphasized the significance of metamaterials in modern technology and shared his team’s recent advancements and future research directions in this field.

Prof. Wu Weiwei began by explaining the working principles of electronic noses and the methodology behind breath diagnosis research. He then detailed his team’s preliminary work addressing bottlenecks in artificial olfactory receptors for electronic noses, including developments in conductive polymer VOC sensor arrays, methods for suppressing humidity interference in sensors, passive VOC sensor arrays using polymer composite films, and clinical urine odor detection for bladder cancer, as well as the team’s efforts in electronic nose system design and manufacturing.

The sessions were chaired by INCSMM vice dean Prof. Ding Liping, and attended by nearly 80 participants, including Prof. Liu Feng from Xi’an Jiaotong University and faculty members and students from the institute.

西安市铁一中学化学组老师来院参观交流

Xi’an Tieyi Middle School chemistry teachers received

2025 年 12 月 25 日下午，西安市铁一中学校长助理沙靖携化学组 30 余位骨干教师来到陕西师范大学新概念传感器与分子材料研究院参观交流。研究院副院长杨小刚向老师们介绍了研究院基本情况、科研团队、科研概况和发展理念，带领他们参观了研究院成果展厅，讲解了房喻院士团队研发的新型膜材料、爆炸物探测仪、毒品探测仪等科研成果转化产品。

铁一中老师们还与化学化工学院领导及学院教师代表等进行了座谈交流，参观了大型科学仪器共享平台。

On December 25, 2025, over 30 chemistry teachers from Xi’an Tieyi Middle School, led by Assistant Principal Sha Jing, visited the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University. INCSMM vice dean Yang Xiaogang introduced the institute’s fundamental conditions, research teams, scientific research, and development philosophy to the visitors, and guided them through the institute’s achievements exhibition room, detailing commercialized products developed by Prof. Fang Yu’s team—including novel membrane materials, explosive detectors, and illicit drugs detection devices.

Teachers from Tieyi Middle School also held discussions with deans and faculty representatives from the School of Chemistry and Chemical Engineering, and toured the large scientific instrument sharing platform.

香港理工大学黄维扬教授应邀作报告

Prof. Wai-yeung Wong from Hong Kong Polytechnic University invited to give a report

2025 年 12 月 26 日上午，香港理工大学黄维扬教授应邀到访陕西师范大学新概念传感器与分子材料研究院，并作题为 Photofunctional Organometallic Materials for Solar Energy Conversion 的学术报告。

黄维扬教授分别从光电 / 光热转化、光催化、光化学等角度出发，系统介绍了课题组开发的各类光电功能有机金属材料的结构 – 性能关系和应用进展。

报告会由刘太宏副教授主持，房喻教授及研究院师生近 50 人参加了报告会。

On December 26, 2025, Prof. Wai-yeung Wong from The Hong Kong Polytechnic University visited the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University, and presented a report titled “Photofunctional Organometallic Materials for Solar Energy Conversion”.

Prof. Wong systematically introduced the structure-property relationships and application progress of various photoelectronic functional organometallic materials developed by his research group, covering aspects such as photoelectric/photothermal conversion, photocatalysis, and photochemistry.

The session was chaired by Assoc. Prof. Liu Taihong. Prof. Fang Yu and nearly 50 faculty members and students from the institute attended the event.

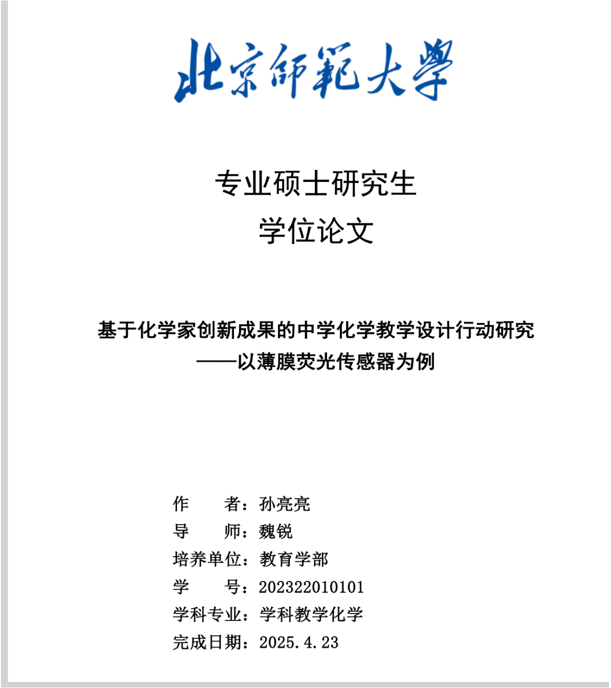
北师大研究生开展“薄膜荧光传感器”教学资源转化研究

BNU master’s student develops teaching resource on “Film-based Fluorescence Sensors”

北京师范大学教育学部学科教学化学专业 2023 级硕士研究生孙亮亮以房喻院士团队的成果“薄膜荧光传感器”为题，开发教学资源并完成其硕士毕业论文《基于化学家创新成果的中学化学教学设计行动研究——以薄膜荧光传感器为例》。

孙亮亮同学在学习期间，通过研读相关文献，当面对房喻院士进行访谈，挖掘学科内容，开发出可供一线教学使用的教学资源，并在人大附中国际部和郑州十一中进行了多轮迭代与实践，探索了基于科学家创新故事的教学素材转化为项目学习的可行性，验证了在学生问题解决能力发展和创新思维发展的有效性，取得了良好的效果。在导师指导下，孙亮亮同学提炼总结出了针对创新成果认识与教学资源开发的方法论，最终完成了硕士学位论文，于今年 5 月通过答辩，并得到了答辩委员会的好评。

孙亮亮同学师从北京师范大学化学学院魏锐教授。魏锐教授现任中国化学会化学教育委员会秘书长、北京师范大学中国教育创新研究院副院长，是《小学科学》杂志（长春出版社，2009）创刊人之一，主要研究方向为化学教育、科学教育与化学哲学，并参与教育部高中化学课程标准修订。



北京师範大學

专业硕士研究生
学位论文

基于化学家创新成果的中学化学教学设计行动研究
——以薄膜荧光传感器为例

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完成日期：2025. 4. 23

Sun Liangliang, a Class of 2025 master’s student in Chemistry Education at the Faculty of Education, Beijing Normal University, developed teaching resources based on the research achievement “Film-based Fluorescent Sensors” by Prof. Fang Yu’s group, and completed his master’s thesis titled “Action Research on Secondary Chemistry Instructional Design Based on Chemists’ Innovative Achievements: The Case of Film-based Fluorescent Sensors.”

During his studies, Sun Liangliang conducted in-depth research by reviewing relevant literature and interviewing Prof. Fang Yu, before exploring disciplinary content and developing teaching resources suitable for frontline instruction. These resources underwent multiple iterations and practical implementation at the International Division of Renmin University High School and Zhengzhou No. 11 High School. This process explored the feasibility of transforming teaching materials based on scientists’ innovation stories into project-based learning. It validated the effectiveness of these resources in developing students’ problem-solving abilities and innovative thinking, yielding positive outcomes. Under his advisor’s guidance, Sun developed a methodology for recognizing innovative achievements and developing teaching resources, and successfully completed his master’s thesis, which he defended in May this year, and received favorable reviews from the thesis defense committee.

Sun Liangliang studied under Prof. Wei Rui at the School of Chemistry, Beijing Normal University. Prof. Wei Rui currently serves as secretary-general of the Chemistry Education Committee of the Chinese Chemical Society and vice dean of the China Education Innovation Research Institute at Beijing Normal University, and is one of the founding editors of the journal Primary Science (Changchun Publishing House, 2009). His primary research focuses on chemistry education, science education, and the philosophy of chemistry, and he has also participated in the revision of the Ministry of Education’s high school chemistry curriculum standards.

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化学：支撑人类文明可持续发展的关键力量

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陕西师范大学/西安交通大学新概念传感器与分子材料研究院；陕西师范大学化学与化工学院，西安 710119

摘要： 简要回顾化学学科的历史作用与当代贡献，探讨化学与物理、生物等学科的相互支撑、协同发展关系。在此基础上，展望化学学科的未来发展，论述化学学科对人类文明可持续发展的不可替代性。谨以此文，恭贺《大学化学》创刊40周年。

关键词： 基础科学；化学教育；原子-分子论；超分子化学；可持续发展
中图分类号： G64；O6

Chemistry: A Key Force Supporting the Sustainable Development of Human Civilization

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Abstract: This article briefly reviews the historical role and contemporary contributions of chemistry. It explores the mutually supportive and symbiotic relationship between chemistry, physics, biology, and other disciplines. Building on this foundation, the article looks ahead to the future of chemistry, discussing its irreplaceable role in the sustainable development of human civilization. This piece is written to celebrate the 40th anniversary of *University Chemistry*, a journal dedicated to chemical education and chemistry teaching.

Key Words: Fundamental science; Chemical education; Atomic-molecular theory; Supra-molecular chemistry; Sustainable development

化学：支撑人类文明可持续发展的关键力量

房 喻

联合国大会将 2022 年确定为“国际基础科学促进可持续发展年”，并于 2023 年 8 月通过《联合国科学促进可持续发展国际十年 (2024–2033 年)》决议，彰显了国际社会对基础科学作为推动人类文明可持续发展关键力量的广泛共识。作为研究物质创造与能量转化的基础学科，化学不仅是揭示自然规律的核心工具，更是改造世界、塑造未来的重要驱动力。化学与物理学、生物学等学科共同构成了人类探索自然、改造自然并提升福祉的科学基础，其发展深度与广度直接关系到人类应对未来挑战、实现可持续发展的能力。

1 化学学科的起源与发展

化学学科在人类长期探索，特别是近几个世纪系统研究的推动下，已发展成为理论体系严密、方法系统成熟的基础科学分支。从拉瓦锡确立质量守恒定律，开启定量化学研究，到道尔顿提出原子论，再到康尼查罗完善原子–分子论，化学逐步建立起“物质由原子构成，原子结合为分子，分子及其聚集态结构决定物质性质”的基本认知框架。这一框架一经建立就构成了化学学科的理论基石，几百年来，未曾被颠覆。

不过，化学的发展从未间断。1987 年、2016 年及 2025 年诺贝尔化学奖先后授予超分子化学、分子机器与框架化学等领域的开创者，标志着化学研究正从传统的共价键强相互作用范畴，拓展至分子间弱相互作用、动态键合、多级组装与结构调控的新阶段，亦即“超分子化学”乃至“适应性化学”阶段。在此过程中，化学家创制新物质的手段不再局限于传统“合成”，“组装”在物质构建中的作用日益凸显。近年来，面向功能应用，人工智能赋能与理性设计下的结构创新研究更加受到关注。2022 年，中国科技大学罗毅、江俊团队推出了能够自动读取云端数据库文献，并据此提出实验方案，然后在室内或在线

控制移动机器人执行包括合成、表征和性能测试等在内的全部实验过程的全能人工智能化学家。2024 年，谷歌 DeepMind 最新版本 AlphaFold 实现了对蛋白质与其他分子相互作用的精准模拟。这些努力无疑可以极大地推动化学科学研究，加速新药物发现。可以说，化学学科发展已经开始进入全新的智能化学阶段，2024 年诺贝尔化学奖授予人工智能学者就充分说明了这一点。

同时，化学研究对象不断丰富，化学测量从物质组成的定性定量分析，扩展至分子结构、聚集体结构的波谱解析、衍射表征、可视化观测乃至单分子与单颗粒水平的物性、结构、反应性测量。动态过程、激发态行为、软物质界面、分子器件以及理论与实验方法的创新，正成为化学研究的新前沿。化学的认知边界持续拓展，学科能力显著提升。在物质创新领域，化学学科实现了从“合成”到“合成 + 组装”，再到“理性设计→(合成 + 组装)”，然后再到“人工智能→理性设计→(合成 + 组装)”的跨越。

2 化学与物理、生物的交叉融合

化学的发展始终与相关学科相互依存、协同演进。化学与物理学的深度融合尤为显著：X– 射线衍射、波谱、时间分辨与成像等物理方法使化学家得以直观解析分子结构、反应动态、激发态过程；量子力学与统计力学则为理论化学的建立与发展奠定了基石。反过来，化学在半导体、低维材料、组装材料、梯度材料、超构材料等物质创制方面的不断突破为物理学探索新现象、总结新规律提供了材料载体，直接推动了工业技术的进步。

化学与生物学的互动同样深刻。化学家建立的原子 – 分子论促使生物学研究从细胞层次迈向分子层次。DNA 双螺旋结构的揭示，本质上是化学键与立体化学原理在生命体系中的具体体现。化学学科的发展催生了生物化学与化学生物学，而生命科学对自我复制、自我修复、自我调节，以及外场感知等生命机制的阐释，也为化学家设计具有“类生命”特征的自适应分子系统提供了灵感，推动化学从制备被动“响应性材料”向创制主动“互动性材料”跨越。

正如华为创始人任正非所指出的，芯片制造不仅依赖设计能力，更取决于制造设备与化学试剂等基础工业水平。这深刻说明，强大的化学学科是尖端科技产业发展的根基。化学是连接微观与宏观世界的桥梁，也是贯通无生命与有生命体系的纽带。化学已经成为理解从原子到物质、从细胞到生命、从生命到意识等一系列根本性变革的依据。可以预见，化学将在破解生命起源、大脑思维、意识本质、碳基生命与硅基智能融合、合成生命、“不可能物质”创制、人工光合成等世纪难题中发挥关键作用。

3 化学与人类可持续发展

化学的使命始终与人类的生存发展紧密相连。在人口增长、气候变化、资源短缺、环境压力日益严峻的背景下，化学作为基础性与驱动性学科，其作用愈发凸显。

在保障全球粮食安全方面化学的作用不可或缺。就提高粮食产量而言，化学贡献具体而深远：现代农业产能很大程度上依赖于化学工业的支撑。据统计，全球约三分之一的粮食产量直接归功于化学肥料的使用。同时，化学农药通过有效防控病虫草害，显著降低了作物产前产后损失。以我国为例，科学施用农药每年可挽回数千万吨粮食损失，约相当于河南省全年粮食总产量，对保障国家粮食供给意义重大而深远。化学的作用不仅在于“增产”，更在于“减损”。从增强作物抗逆性的生长调节剂，到防治储粮霉变与虫害的熏蒸剂与防护剂，化学技术贯穿“从田间到餐桌”全链条，最大限度降低粮食损耗。此外，化学测量技术构建起严密的农产品安全监测网络，对农药残留、重金属污染等风险实施精准管控，在保障产量的同时守护质量安全。可以说，化学在构建全球与国家粮食安全体系中扮演着多重不可替代的角色。

在人类健康领域，化学同样发挥着关键作用。青蒿素这一源自中药并经化学提取、修饰与验证的药物的发现与应用，已拯救了全球数亿人免于疟疾威胁，成为化学与生命科学交叉服务人类健康的典范。随着合成化学、药物化学与化学测量技术的进步，现代医药工业持续推动抗生素、疫苗、靶向药物及创新疗法的研发，为应对多样性疾病提供日益精准的药物选择。化学还在疾病预防、诊断与健康管理等多层面构筑防线：在预防层面，化学消毒与营养强化技术降低了传染病传播风险；在诊断层面，免疫分析、分子探针与医学影像等技术为早期精准诊断提供核心工具。此外，化学在药物制剂、医用材料与营养评估等方面的创新，正推动全周期健康保障体系的构建。

在推动能源体系绿色转型方面，化学居于核心地位。面对气候变化挑战，化学家在“开源”与“节流”两端寻求突破：在“开源”方面，晶硅电池、钙钛矿太阳能电池等新型光伏技术的光电转换效率在化学材料创新推动下不断刷新，为低成本高效捕获光能奠定基础；在“节流”与储能方面，化学原理深化应用驱动电池能量密度与循环寿命持续提升；电催化或光催化水分解制“绿氢”技术，则为间歇性可再生能源转化为可储存化学能提供了可行路径。这些技术进步均源于化学家对物质结构与性能关系的深刻理解，通过分子设计、界面调控与反应工程，创制功能材料，揭示能量转换微观机制，最终实现能源效率优化。化学的基础创新为“双碳”目标实现与新型能源系统构建提供了科学与技术支撑。

4 化学学科的变革与愿景

化学科学研究正经历一场深刻的范式变革。其研究重心已不再局限于分子尺度的结构、合成方法、组装工艺的创新，或是对材料多功能性的单纯追求，而是逐渐转向在多层次、多尺度的复杂体系中，实现对分子结构、分子行为、反应路径与系统性质的精准理解、可靠预测及主动调控。这一转型不仅依赖于对分子间相互作用与反应机理的深刻认识，更需融合先进表征技术、理论模拟、数据科学与人工智能等方法，从而在介观乃至宏观尺度上实现对化学过程的高时空分辨操控。这标志着化学研究正从“揭示和认识规律”向“按需设计与理性调控”跨越，为能源、医疗、环境、材料等关键领域提供更加精准与智能的解决方案。同时，也对当代化学工作者提出了更高要求，这就是必须构建跨学科的知识结构与创新能力，成为能够在交叉领域开展创新研究、解决真问题、满足真需求的复合型人才，亦即，产业界所呼唤的“交叉创新人才”。

在可预见的未来，化学学科需发展原子经济性反应与绿色合成路径，从源头化解物质创制与能量转化过程中的环境压力；需借助人工智能与大数据技术，实现新分子、新材料的精准设计、合成与组装过程的自动化与智能化；还需创制具备感知、计算、响应乃至自修复能力的“智能物质”系统，在师法自然的基础上实现超越。通过支撑量子科技、合成生物学、太空探索、人类增强、毫米波通讯、太赫兹探测等未来技术的发展，更好地满足国家战略需求，服务人类文明可持续发展，彰显化学学科的不可替代价值。

《道德经》有言：“万物之始，大道至简，衍化至繁”。化学学科的发展正是这一哲思的生动体现，化学从原子、分子等基本单元出发，逐步构筑起结构与功能趋于无限丰富的物质世界。这一认知历程不仅赋予人类理解与改造物质世界的能力，也塑造了化学工作者严谨求实的思维习惯与精益求精的处事态度，可谓“思及细微，行于精谨”。化学因其基础性而成为科学体系的基石，因其渗透性而融入众多科技领域，因其应用性而持续推动技术革新，更因其不断演进而永葆生机。这些特质共同铸就了化学“顶天立地”的学科品格。

化学从来不是一座孤岛。它是基础科学与工程技术、无生命与有生命物质之间的关键桥梁，是支撑材料、能源、环境、生命、信息等几乎所有科技领域发展的核心支柱。自其形成体系以来，化学始终默默推动着人类文明的进程。可以说，化学对于国家现代化建设、民族复兴以及人类文明的可持续发展，具有不可替代的基础性作用。诚然，化学不能解决所有问题，但若没有化学，现代文明的一切成就都将无从谈起。化学即未来，没有化学，我们所能设想的那个可持续的美好明天也将失去根基。

5 结语

回望历史，实践已作出公正评判：任何对化学的污名化与片面指责，皆为缺乏远见的短视行为。正是化学，一次次将人类从饥馑与疾病中解救出来，为现代社会的运转奠定了坚实的物质基础。展望前路，从实现碳中和的宏伟目标，到构建万物循环的零废未来，我们比以往任何时候都更加需要化学，以及那些在实验室中默默耕耘的化学工作者。他们的探索，不仅关乎地球的未来，也关乎我们全人类共同的、可持续的明天。

为此，我们必须致敬《大学化学》，致敬其数十载如一日坚持为化学正名、坚持为化学教育改革发展鼓与呼。

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Chemistry: A Key Force Supporting the Sustainable Development of Human Civilization

Fang Yu

The United Nations General Assembly designated 2022 as the “International Year of Basic Sciences for Sustainable Development” and adopted the resolution on the United Nations Decade of Science for Sustainable Development (2024–2033) in August 2023, underscoring the international community's broad consensus on the pivotal role of basic sciences in advancing sustainable development for human civilization. As a fundamental discipline studying the creation of matter and transformation of energy, chemistry serves not only as a core tool for revealing natural laws but also as a vital driving force for reshaping the world and shaping the future. Together with physics, biology, and other disciplines, chemistry forms the scientific foundation for humanity's exploration and transformation of nature to enhance well-being. The depth and breadth of its development directly impact humanity's capacity to address future challenges and achieve sustainable development.

1 The Origin and Development of Chemistry

The discipline of chemistry has

evolved into a fundamental branch of science with a rigorous theoretical framework and mature methodological systems, driven by humanity's long-term exploration and particularly by systematic research over the past few centuries. From Lavoisier's establishment of the law of conservation of mass, which initiated quantitative chemical research, to Dalton's atomic theory, and further to Cannizzaro's refinement of the atomic-molecular theory, chemistry gradually established the fundamental conceptual framework: "Matter is composed of atoms; atoms combine to form molecules; and the structure of molecules and their aggregated states determines the properties of matter." Once established, this framework became the theoretical cornerstone of chemistry, remaining unchallenged for centuries.

However, the advancement of chemistry has never ceased. The Nobel Prizes in Chemistry awarded in 1987, 2016, and 2025 recognized pioneers in supramolecular chemistry, molecular machines, and framework chemistry, respectively. This signifies that chemical research is expanding beyond the traditional realm of strong covalent bonding interactions into a new phase characterized by intermolecular weak interactions, dynamic bonding, multilevel assembly, and structural regulation—the era of "supramolecular chemistry" and even "adaptive chemistry." In this process, chemists' methods for creating new substances are no longer confined to traditional "synthesis," with "assembly" playing an increasingly prominent role in material construction. In recent years, research on structural innovation driven by artificial intelligence and rational design for functional applications has garnered increasing attention. In 2022, the team led by Luo Yi and Jiang Jun at the University of Science and Technology of China introduced an all-in-one AI chemist capable of autonomously retrieving literature from cloud databases, proposing experimental protocols based on this information, and then controlling mobile robots in the lab or online to execute the entire experimental process—including synthesis, characterization, and performance testing. In 2024, Google DeepMind's latest version of AlphaFold achieved precise simulations of protein interactions with other molecules. These efforts undoubtedly hold immense potential to advance chemical research and accelerate new drug discovery. It can be said that the field of chemistry has entered a new era of intelligent chemistry, a fact underscored by the 2024 Nobel Prize in Chemistry being awarded to artificial intelligence researchers.

Meanwhile, the scope of chemical research subjects continues to expand. Chemical measurement has evolved from qualitative and quantitative analysis of material composition to include spectral analysis of molecular and aggregate structures, diffraction characterization, visualization techniques, and even measurements of physical properties, structures, and reactivity at the single-molecule and single-particle levels. Dynamic processes, excited-state behavior, soft matter interfaces, molecular devices, and innovations in theoretical and experimental methods are emerging as new frontiers in chemical research. The cognitive boundaries of chemistry continue to expand, with significant enhancements in the discipline's capabilities. In the realm of material innovation, chemistry has achieved a transformative leap: from "synthesis" to "synthesis + assembly," then to "rational design → (synthesis + assembly)," and finally to "artificial intelligence → rational design → (synthesis + assembly)."

2. The Integration of Chemistry with Physics and Biology

The development of chemistry has always been interdependent and co-evolved with related disciplines. Its deep integration with physics is particularly evident: physical methods such as X-ray diffraction, spectroscopy, time-resolved techniques, and imaging enable chemists to visually analyze molecular structures, reaction dynamics, and excited-state processes; quantum mechanics and statistical mechanics laid the foundation for the establishment and advancement of theoretical chemistry. Conversely, chemistry's continuous breakthroughs in creating novel materials—such as semiconductors, low-dimensional materials, assembled materials, gradient materials, and metamaterials—have provided physical carriers for physics to explore new phenomena and formulate new laws, directly propelling industrial technological advancement.

The interaction between chemistry and biology is equally profound. The atomic-molecular theory established by chemists propelled biological research from the cellular level to the molecular level. The revelation of the DNA double helix structure is, at its core, a concrete manifestation of chemical bonds and stereochemical principles within living systems. The advancement of chemistry gave rise to biochemistry and chemical biology. Meanwhile, life sciences' elucidation of mechanisms such as self-replication, self-repair, self-regulation, and external field perception has inspired chemists to design adaptive molecular systems with "life-like" characteristics. This has propelled chemistry from preparing passive "responsive materials" to creating active "interactive materials."

As Huawei founder Ren Zhengfei has pointed out, chip manufacturing relies not only on design capabilities but also on the level of foundational industries such as manufacturing equipment and chemical reagents. This profoundly illustrates that a robust chemical discipline is the bedrock for the development of cutting-edge technology industries. Chemistry bridges the microscopic and macroscopic worlds, serving as the connecting thread between inanimate and living systems. It has become the cornerstone for understanding fundamental transformations—from atoms to matter, from cells to life, and from life to consciousness. It is foreseeable that chemistry will play a pivotal role in solving century-old challenges: unraveling the origins of life, deciphering brain cognition, exploring the essence of consciousness, integrating carbon-based life with silicon-based intelligence, synthesizing life, creating "impossible substances," and achieving artificial photosynthesis.

3 Chemistry and Human Sustainable Development

The mission of chemistry has always been inextricably linked to human survival and development. Against the backdrop of population growth, climate change, resource scarcity, and mounting environmental pressures, chemistry—as a foundational and driving discipline—is playing an increasingly vital role.

Chemistry plays an indispensable role in ensuring global food security. In terms of boosting food production, its contributions are both tangible and profound: modern agricultural productivity relies heavily on the support of the chemical industry. Statistics indicate that approximately one-third of the world's food production is directly attributable to the use of chemical fertilizers. Simultaneously, chemical pesticides significantly reduce pre- and post-harvest crop losses by effectively controlling pests, diseases, and weeds. Taking China as an example, the scientific application of pesticides can prevent tens of millions of tons of grain losses annually—roughly equivalent to Henan Province's total annual grain output—making it of profound and far-reaching significance for safeguarding the nation's food supply. The role of chemistry extends beyond merely "increasing production" to "reducing losses." From growth regulators that enhance crop stress resistance to fumigants and protective agents that prevent mold and insect infestation in stored grain, chemical technologies span the entire "farm-to-table" chain, minimizing grain losses to the greatest extent possible. Moreover, chemical measurement technologies have established a rigorous agricultural product safety monitoring network, enabling precise control over risks such as pesticide residues and heavy metal contamination. This approach safeguards both yield and quality while ensuring food safety. Indeed, chemistry plays multiple irreplaceable roles in building global and national food security systems.

In the realm of human health, chemistry also plays a pivotal role. The discovery and application of artemisinin—a drug derived from traditional Chinese medicine through chemical extraction, modification, and validation—has saved hundreds of millions worldwide from malaria, exemplifying how chemistry and life sciences intersect to serve human health. Advances in synthetic chemistry, medicinal chemistry, and chemical measurement technologies continue to propel the modern pharmaceutical industry in developing antibiotics, vaccines, targeted drugs, and innovative therapies, providing increasingly precise drug options to address diverse diseases. Chemistry also builds defenses across multiple levels of disease prevention, diagnosis, and health management: At the prevention level, chemical disinfection and nutritional fortification technologies reduce the risk of infectious disease transmission; at the diagnosis level, techniques such as immunoassays, molecular probes, and medical imaging provide core tools for early and precise diagnosis. Furthermore, innovations in pharmaceutical formulation, medical materials, and nutritional assessment are driving the establishment of a comprehensive health security system.

Chemistry plays a central role in advancing the green transformation of energy systems. In addressing climate change challenges, chemists pursue breakthroughs on both fronts of "expanding sources" and "conserving resources": On the "expanding sources" front, the photoelectric conversion efficiency of novel photovoltaic technologies like crystalline silicon cells and perovskite solar cells continues to be redefined through chemical material innovations, laying the foundation for low-cost, high-efficiency capture of solar energy; In "conserving resources" and energy storage, the deepening application of chemical principles is driving continuous improvements in battery energy density and cycle life. Electrocatalytic or photocatalytic water-splitting technologies for producing "green hydrogen" offer a viable pathway for converting intermittent renewable energy into storable chemical energy. These technological advancements stem from chemists' profound understanding of the relationship between material structure and properties. Through molecular design, interfacial control, and reaction engineering, they create functional materials, uncover the microscopic mechanisms of energy conversion, and ultimately achieve optimized energy efficiency. Fundamental innovations in chemistry provide the scientific and technological foundation for realizing the dual carbon goals and constructing new energy systems.

4. Transformation and Vision in the Chemistry Discipline

Chemical science research is undergoing a profound paradigm shift. Its focus has expanded beyond innovations in molecular-scale structures, synthetic methods, and assembly techniques, or the mere pursuit of multifunctional materials. Instead, it is increasingly directed toward achieving precise understanding, reliable prediction, and active control of molecular structures, molecular behavior, reaction pathways, and system properties within complex, multilevel, and multiscale systems. This transformation relies not only on a profound understanding of intermolecular interactions and reaction mechanisms, but also requires the integration of advanced characterization techniques, theoretical simulations, data science, and artificial intelligence. This enables high spatiotemporal resolution manipulation of chemical processes at the mesoscopic and even macroscopic scales. It signifies a leap in chemical research from “uncovering and understanding principles” to “on-demand design and rational regulation,” providing more precise and intelligent solutions for critical fields such as energy, healthcare, environment, and materials. At the same time, this places higher demands on contemporary chemists: they must build interdisciplinary knowledge structures and innovative capabilities to become versatile professionals capable of conducting innovative research across disciplines, solving real-world problems, and meeting genuine needs—that is, the “interdisciplinary innovators” sought by industry.

In the foreseeable future, the discipline of chemistry must advance atom-economical reactions and green synthetic pathways to mitigate environmental pressures at the source during material creation and energy conversion processes. It must leverage artificial intelligence and big data technologies to achieve automation and intelligence in the precise design, synthesis, and assembly of new molecules and materials. Furthermore, it must develop “intelligent material” systems capable of sensing, computing, responding, and even self-repairing—transcending nature while drawing inspiration from it. By underpinning the advancement of future technologies—including quantum science, synthetic biology, space exploration, human augmentation, millimeter-wave communication, and terahertz detection—chemistry will better serve national strategic needs, support the sustainable development of human civilization, and demonstrate its irreplaceable value.

The Tao Te Ching states: “At the beginning of all things, the Great Way is simple; through evolution, it becomes complex.” The development of chemistry vividly embodies this philosophical insight. Starting from fundamental units like atoms and molecules, chemistry has progressively constructed a material world of infinitely rich structures and functions. This cognitive journey not only endows humanity with the ability to understand and transform the material world but also shapes chemists' rigorous, pragmatic thinking habits and meticulous approach to work—truly “contemplating the minute and acting with precision.” Chemistry serves as the cornerstone of the scientific system due to its foundational nature. Its pervasive influence integrates it into numerous scientific and technological fields. Its applied nature continuously drives technological innovation. And its constant evolution ensures its enduring vitality. These characteristics collectively forge chemistry's distinctive character as a discipline that “reaches the heavens and grounds itself in the earth.”

Chemistry has never been an isolated island. It serves as a vital bridge between fundamental science and engineering technology, between inanimate and living matter, and stands as the core pillar supporting the advancement of nearly all scientific and technological fields—including materials, energy, environment, life sciences, and information technology. Since its emergence as a systematic discipline, chemistry has consistently and quietly propelled the progress of human civilization. It can be said that chemistry plays an irreplaceable foundational role in national modernization, national rejuvenation, and the sustainable development of human civilization. Admittedly, chemistry cannot solve every problem. Yet without it, none of modern civilization's achievements would exist. Chemistry is the future. Without it, the sustainable tomorrow we envision would lose its very foundation.

5 Conclusion

Looking back at history, practice has delivered a fair verdict: any stigmatization or one-sided criticism of chemistry is a short-sighted act lacking foresight. It is chemistry that has repeatedly rescued humanity from famine and disease, laying a solid material foundation for the functioning of modern society. Looking ahead, from achieving the grand goal of carbon neutrality to building a zero-waste future where everything recycles, we need chemistry—and the chemists diligently working in laboratories—more than ever before. Their explorations concern not only the future of our planet but also the sustainable tomorrow shared by all humanity.

For this reason, we must pay tribute to University Chemistry, honoring its decades of unwavering dedication to restoring chemistry's reputation and championing the reform and advancement of chemistry education.

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