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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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研究院教师获 6 项国家自然科学基金项目资助

Six INCSMM teachers funded by National Natural Science Foundation of China

近日，国家自然科学基金委公布了 2026 年度国家自然科学基金项目资助结果，新概念传感器与分子材料研究院 6 位教师获得资助。

边红涛教授、刘凯强教授、马佳妮教授和彭浩南教授、获批国家自然科学基金面上项目，分别获资助经费 50 万元；青年教师赵智豪博士、博士

后林思敏博士获批国家自然科学基金青年项目，分别获资助经费 30 万元。

负责人	项目名称	经 费	项目类别
边红涛	外电场作用下水系电解质结构及动力学的超快红外光谱研究	50 万	面上项目
刘凯强	多级链间酯交换可逆界面黏附的热调控机制	50 万	面上项目
马佳妮	近红外响应的高效 BODIPY 光笼分子的理性设计及机制研究	50 万	面上项目
彭浩南	传感界面构建：单组分激发波长依赖多色发光及其调控机制	50 万	面上项目
赵智豪	荧光纳米膜的界面限域生长机制及气体传质 – 传感耦合行为研究	30 万	青年项目
林思敏	分子晶体疏水空腔中水簇的形成与稳定机制	30 万	青年项目

Recently, the National Natural Science Foundation of China announced the results of its 2026 grant awards, and six faculty members from the Institute of New Concept Sensors and Molecular

Materials received funding.

Professors Bian Hongtao, Liu Kaiqiang, Ma Jiani and Peng Haonan were awarded General Programs grants, each receiving CNY 500,000 yuan in

funding; young teacher Dr. Zhao Zhihao and postdoctoral researcher Dr. Lin Simin were awarded Young Scientists Programs grants, each receiving CNY 300,000 yuan in funding.

PI	Project Name
Bian Hongtao	Ultrafast Infrared Spectroscopic Study of the Structure and Kinetics of Aqueous Electrolytes Under the Influence of an External Electric Field
Liu Kaiqiang	Thermal Regulation Mechanisms of Reversible Interfacial Adhesion via Multistep Interchain Ester Exchange
Ma Jiani	Rational Design and Mechanism Study of Highly Efficient BODIPY Photocage Molecules with Near-Infrared Responsiveness
Peng Haonan	Sensor Interface Construction: Wavelength-Dependent Multicolor Luminescence from a Single Component and Its Control Mechanisms
Zhao Zhihao	A Study on the Interface-Confined Growth Mechanism and Gas Mass Transfer–Sensing Coupling Behavior of Fluorescent Nanomembranes
Lin Simin	Mechanisms of Water Cluster Formation and Stability in Hydrophobic Cavities of Molecular Crystals

学校学院领导看望慰问房喻院士

School officials visit Fang Yu ahead of Teachers' Day



On the morning of September 9, 2026, ahead of China's 42nd Teachers' Day, Chen Xinbing, deputy secretary of the Party Committee and president of Shaanxi Normal University, visited Prof. Fang Yu at the Institute of New Concept Sensors and Molecular Materials to

extend festive greetings and best wishes.

SNNU Party Committee deputy secretary Luo Yonghui, School of Chemistry and Chemical Engineering Party Committee secretary Li Baoxin, and SCCE dean Liu Chenghui, accompanied the visit.

2026年9月9日上午，在第42个教师节来临之际，陕西师范大学党委副书记、校长陈新兵一行来到新概念传感器与分子材料研究院看望慰问房喻院士，致以节日的问候和祝福，并与房喻院士座谈交流。

党委副书记罗永辉，化学化工学院党委书记李保新、院长刘成辉陪同慰问。

同日上午，学校科学技术处处长薛东一行、化学化工学院领导班子一行、学校教务处处长翟全国一行看望慰问了房喻院士。

That same morning, SNNU Department of Science and Technology director Xue Dong, the SCCE leadership, along with leadership of SNNU Office of Teaching Affairs led by director Zhai Quan Guo, visited and extended their regards to Prof. Fang Yu.

研究院开展研究生新生入学教育暨安全保密培训

Orientation and Safety and Confidentiality Training for new graduate students held

2026年9月28日，陕西师范大学新概念传感器与分子材料研究院召开2026级研究生新生入学教育暨安全保密培训会。丁立平副院长主持会议并对全体新生的到来表示欢迎，全院近百名师生参会学习。

会上，刘凯强教授介绍了研究院整体情况，包括理念架构、人员编制与主要研究方向等，围绕传承与创新开展教育培训。

在实验室安全专题培训环节，薄鑫副研究员讲解了仪器操作、试剂管理、危废处置及应急处置流程，并结合典型案例强调实验纪律，筑牢实验室安全防线。

左振男老师从保密法律法规、常见泄密风险点、典型案例分析和保密行为规范等四个方面进行了保密专题培训，此外还解读了门禁系统使用规范。

On September 28, 2026, the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University held an orientation session and safety and confidentiality training session for the incoming class of 2026 graduate students. Vice dean Prof. Ding Liping chaired the meeting and



welcomed the new students, which was attended by nearly 100 faculty members and students.

At the meeting, Prof. Liu Kaiqiang provided an overview of the institute, including its philosophy, organizational structure, staffing, and primary research areas, focusing on the themes of tradition and innovation.

Assoc. Prof. Bo Xin led a training session on laboratory

safety, covering instrument operation, reagent management, hazardous waste disposal, and emergency response procedures. Drawing on typical case studies, he emphasized the importance of laboratory discipline to strengthen safety

protocols.

Mr. Zuo Zhennan conducted a training session on confidentiality, covering four key areas: confidentiality laws and regulations, common risks of information leaks, analysis of

typical cases, and codes of conduct for confidentiality. He also explained the guidelines for using the access control system.



研究院 2025 级硕士研究生论文开题

Class of 2028 Master's Thesis Proposal Presentation sessions held

2026 年 9 月 29 日和 30 日，陕西师范大学新概念传感器与分子材料研究院组织 2025 级硕士研究生进行毕业论文开题汇报。

硕士研究生 42 人分为四组进行了开题汇报，丁立平教授、刘静教授、刘凯强教授分别担任评委组长，研究院其他教师担任评委。研究生同学回答了评委老师提出的问题，评委老师

针对同学们的课题工作进行了讨论和指导。

On September 29 and 30, 2026, the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University organized graduation thesis proposal presentation sessions for the Class of 2028 master's students.

Forty-two master's students were

divided into four groups to present their thesis proposals. Professors Ding Liping, Liu Jing, and Liu Kaiqiang served as judge leaders, respectively, while other faculty members from the institute served as judges. The graduate students answered the questions posed by the judges, who then discussed and provided guidance on the students' projects.



▷ 2026 年 9 月 1 日，房喻院士为参加陕西师范大学 2026 年新进校教职工岗前培训作题为“科学的价值与教育的作用”的专题报告。

▷ On September 1, 2026, Prof. Fang Yu delivered a lecture titled “The Value of Science and the Role of Education” to new faculty and staff at Shaanxi Normal University as part of their 2026 pre-service training program.



▷ 2026 年 9 月 4 日，房喻院士应邀出席在长安云·西安科技馆举行的 2026 年西安市全国科普月主场活动启动仪式，并为第 40 届全国青少年科技创新大赛获奖选手颁奖。

▷ On September 4, 2026, Prof. Fang Yu attended the launch ceremony for the 2026 Xi'an National Science Popularization Month main events, held at Chang'an Cloud - Xi'an Science and Technology Museum, where he presented awards to the winners of the 40th National Youth Science and Technology Innovation Competition.



▷ 2026 年 9 月 8 日，房喻院士作为国家教材委员会委员在北京参加了全国教材工作会议。中共中央政治局常委、国务院副总理丁薛祥出席会议并讲话。

▷ On September 8, 2026, Prof. Fang Yu, as a member of the National Textbook Committee, attended the National Textbook Work Conference in Beijing. Ding Xuexiang, a member of the Standing Committee of the Political Bureau of the CPC Central Committee and vice premier of the State Council, attended the conference and delivered a speech.

▷ 新概念传感器与分子材料研究院赵智豪博士后和林思敏博士后获批资助，其中赵智豪获批 2026 年度国家资助博士后研究人员计划（B 档），赵智豪、林思敏获批中国博士后科学基金第 79 批面上资助。

▷ Recently, postdoctoral researchers Zhao Zhihao and Lin Simin from the Institute of New Concept Sensors and Molecular Materials were awarded funding. Specifically, Zhao Zhihao was approved for the 2026 National Postdoctoral Researcher Funding Program (Category B), while both Zhao Zhihao and Lin Simin were awarded general grants under the 79th batch of the China Postdoctoral Science Foundation.

▷ 近日，新概念传感器与分子材料研究院薄鑫副研究员指导研究生胡金凤、赵雅婷参加了第五届全国大学生电化学测量技术竞赛，并获西北赛区研究生组别二等奖。

▷ Recently, Assoc. Prof. Bo Xin (as an adviser) from the Institute of New Concept Sensors and Molecular Materials and graduate students Hu Jinfeng and Zhao Yating (as contestants) participated in the 5th National Electrochemical Measurement Techniques Competition for College Students, where they won second prize in the graduate student category of the Northwest Regional Competition.



▷ 2026 年 9 月 15 日，房喻院士出席了在西安举办的首届丝路科幻大会主场活动启动仪式。

▷ On September 15, 2026, Prof. Fang Yu attended the launch ceremony for the main event of the First Silk Road Science Fiction Conference held in Xi'an.



▷ 近期，光子科技实验室公布了 2026 年立项科技项目，陕西师范大学新概念传感器与分子材料研究院刘太宏教授的项目“凝聚态激发态调控驱动智能传感新机制”获批资助，资助经费为 30 万元。

▷ Recently, the Photonics Technology Laboratory announced the list of science and technology projects approved for 2026, and the project titled “New Mechanisms for Intelligent Sensing Driven by the Control of Excited States in Condensates” by Prof. Liu Taihong of the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University was approved for funding in the amount of CNY 300,000 yuan.

▷ 2026 年 9 月 19 日上午，房喻院士在兰州市出席了兰州大学化学学科创建 80 周年暨高质量发展大会。

▷ On September 19, 2026, Prof. Fang Yu attended the conference commemorating the 80th anniversary of the establishment of the chemistry discipline at Lanzhou University and promoting its high-quality development in Lanzhou.

▷ 2026 年 9 月 29 日，房喻院士作为专家组专家出席了西安交通大学教育部工程研究中心建设项目验收会。

▷ On September 29, 2026, Prof. Fang Yu, serving as a member of the expert panel, attended the acceptance meeting for the construction project of the Ministry of Education Engineering Research Center at Xi'an Jiaotong University.

▷ 2026 年 9 月 29 日，陕西师范大学新概念传感器与分子材料研究院副院长杨小刚、西安方格分子材料科技有限公司总经理韩鹏、研发工程师田哲携薄膜荧光传感器、防水拒油透气膜及高性能可定制介电材料等研究院研发技术和产品参加了宿迁市 2026 绿色产业洽谈会。

▷ On September 29, 2026, Yang Xiaogang, vice dean of the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University; Han Peng, general manager of Xi'an Fonge Molecular Materials Technology Co., Ltd.; and R&D Engineer Tian Zhe, attended the 2026 Suqian Green Industry Trade Fair, showcasing technologies and products developed by the institute, including film fluorescent sensors, water- and oil-repellent breathable membranes, and high-performance customizable dielectric materials.



绿色 · 跨界 · 融合 · 对接
Green-oriented · Interdisciplinary · Fusing · Docking

中电科 38 所和西交大一行来访 CETC 38th Institute and XJTU guests received

2026 年 9 月 4 日下午，中国电子科技集团公司第三十八研究所军工市场总监郭俊、微波中心副主任张小林、西安交通大学陈娟教授、衣建甲教授到访陕西师范大学新概念传感器与分子材料研究院，与房喻院士就高性能介电材料的应用需求进行了交流与探讨。研究院副院长丁立平教授、副院长杨小刚、彭军霞教授及研发工程师何怡楠参加了座谈交流。

On September 4, 2026, Military Market director Guo Jun and Microwave Center deputy director Zhang Xiaolin at the 38th Research Institute of China Electronics Technology Group Corporation; and Professors Chen Juan and Yi Jianjia from Xi'an Jiaotong University visited the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University to discuss



the application needs of high-performance dielectric materials with Prof. Fang Yu. INCSMM vice dean Prof. Ding Liping,

vice dean Mr. Yang Xiaogang, Prof. Peng Junxia and R&D Engineer He Yinan participated in the discussion.

陕西省科技厅来院调研座谈 Shaanxi Department of Science and Technology officials received



2026 年 9 月 16 日上午，陕西省科学技术厅副厅长冀峰一行来到陕西师范大学新概念传感器与分子材料研究院调研座谈。

冀峰一行听取了研究院副院长杨小刚对研究院基本情况及高性能介电材料研发情况的介绍汇报，参观了研究院成果展厅，并与房喻院士进行了座谈交流。

省科技厅产业创新促进处处长周莹、办公室副主任王鹏鹏、资源配置与管理处(重大专项处)副处长杨宝林，陕西师范大学副校长周正朝、科学技术处处长薛东、化学化工学院党委书记李保新、科技处副处长曹晓仪及研

究院研发工程师王佩、何怡楠陪同调研并参加座谈。

On September 16, 2026, Ji Feng, deputy director of the Shaanxi Provincial Department of Science and Technology, visited the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University for a inspection visit and roundtable discussion.

Ji Feng and his delegation listened to a presentation by INCSMM vice dean

Mr. Yang Xiaogang, on the institute's general overview and its research and development efforts in high-performance dielectric materials; toured the institute's exhibition room showcasing its achievements; and held a discussion with Prof. Fang Yu.

Shaanxi Department of Science and Technology Industrial Innovation Promotion Division director Zhou Ying, General Office deputy director Wang Pengpeng, and Resource Allocation

and Management Division (Major Special Projects Division) deputy director Yang Baolin; as well as Shaanxi Normal University vice president Zhou Zhengchao, Department of Science and Technology director Xue Dong, School of Chemistry and Chemical Engineering Party Committee Secretary Li Baoxin, S&T Department deputy director Cao Xiaoyi, and R&D engineers Wang Pei and He Yinan, accompanied the visit and attended discussion session.

陕西省技术经理人培训班学员来院参观

Shaanxi Province Technology Transfer Manager Training Program participants received



2026 年 9 月 17 日，由陕西省科技资源统筹中心组织的陕西省技术经理人培训班 90 余名学员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为培训班学员作了题为“新概念传感器与分子材料研究院科技成果转化情况介绍”的报告，介绍了研究院基本情况及研发的新概念传感器、高端防水拒油透气膜和高性能介电材料。

报告结束后，杨小刚还带领学员们参观了成果展厅，并与他们就高校技术成果转移转化队伍建设和推动科

技成果转化落地等问题进行了交流。

On September 17, 2026, more than 90 participants in the Shaanxi Province Technology Transfer Manager Training Program, organized by the Shaanxi Provincial Science and Technology Resource Coordination Center, visited the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University.

INCSMM vice dean Mr. Yang Xiaogang presented a report titled “Technology Transfer at Institute of New Concept Sensors and Molecular

Materials” to the training program participants. He provided an overview of the institute and introduced the new concept sensors, high-end water- and oil-repellent breathable membranes, and high-performance dielectric materials developed by the institute.

After the presentation, Yang Xiaogang also led the participants on a tour of the achievements exhibition room and exchanged views with them on issues such as building teams for the transfer and commercialization of university technology achievements and promoting the practical application of scientific and technological achievements.

上海博取仪器有限公司一行来访 Shanghai Boqu Instruments visitors received

2026年9月18日，上海博取仪器有限公司董事长崔永海一行到访陕西师范大学新概念传感器与分子材料研究院，并进行参观交流。

研究院李萌副研究员、研发工程师王佩向来宾介绍了研究院概况、人员及研发产品等情况。西安方格分子材料科技有限公司总经理韩鹏、副总经理陈博陪同参观并参加交流。

On September 18, 2026, a delegation led by Cui Yonghai, chairman of Shanghai Boqu Instruments Co., Ltd., visited the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University.

Assoc. Prof. Li Meng and R&D engineer Wang Pei briefed the guests on the institute's overview, faculty and staff, and research and development products. Xi'an Fangge



Molecular Materials Technology Co., Ltd. general manager Han Peng and deputy general manager Chen Bo joined the guests on the tour and exchange.

大连化学物理研究所吴凯丰研究员应邀作报告

Wu Kaifeng from CAS Dalian Institute of Chemical Physics invited to give a report



2026年9月28日上午，中国科学院大连化学物理研究所吴凯丰研究员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“三线态激发态动力学量子调控”的学术报告。

吴凯丰研究员的报告聚焦于在“温暖湿润”条件下的化学材料体系中是否存在量子相干效应，及能否借助量子效应对这些化学反应和材料性能实现量子层面的调控。

报告会由边红涛教授主持，房喻院士以及30多名研究院师生参加了报告会。

On September 28, 2026, Researcher Wu Kaifeng from the Dalian Institute of Chemical

Physics, Chinese Academy of Sciences, was invited to visit the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University, where he presented a report titled “Quantum Control of Triplet Excitation State Dynamics”.

Wu Kaifeng's presentation focused on whether quantum coherence effects exist in chemical material systems under “warm

and humid” conditions, and whether these quantum effects can be harnessed to achieve quantum-level control over these chemical reactions and material properties.

The report was moderated by Prof. Bian Hongtao and attended by Prof. Fang Yu and more than 30 faculty members and students from the institute.

Robust Fluorescent Eutectogel with Temperature Resilience and Microenvironment-Regulated Emission for Stimuli-Responsivity

Published as part of The Journal of Physical Chemistry B special issue “Yu Fang Festschrift”.

Huanhuan Dong,[†] Xinyu Gou,[†] Nianhua Zhao, Weina Wang, Yu Fang*, and Junxia Peng*



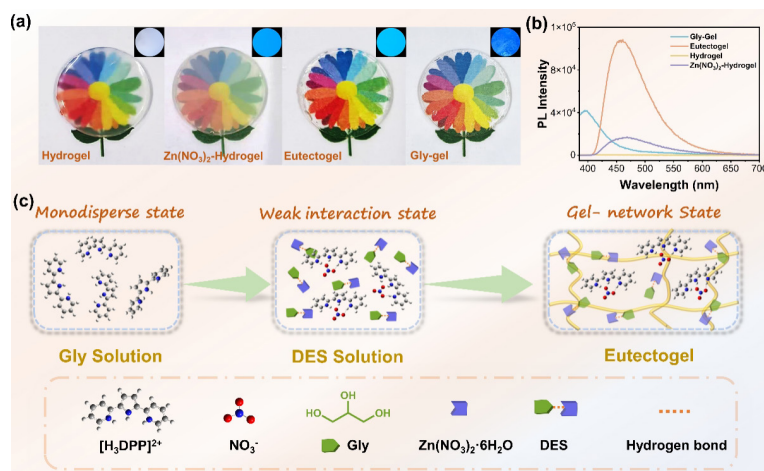
Cite This: *J. Phys. Chem. B* 2026, 130, 9313–9325



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具有优异耐温性和微环境调控发射特性的高稳定性刺激响应型荧光低共熔凝胶

Huanhuan Dong#, Xinyu Gou#, Nianhua Zhao, Weina Wang, Yu Fang*, Junxia Peng*, *J. Phys. Chem. B*, 2026. <https://doi.org/10.1021/acs.jpccb.6c04332>



荧光低共熔凝胶是一类新兴的智能材料，它将低共熔溶剂（DESs）独特的微环境、优异的耐温性和环境友好性融为一体，推动了柔性光学材料和信息加密领域的快速发展。

在本研究中，我们将环境敏感型阳离子发光体 2,5-双(2-吡啶鎓基)-1H-吡咯双(六氟磷酸盐) ([H₃DPP]²⁺) 引入甘油/Zn(NO₃)₂·6H₂O 低共熔溶剂中，随后通过丙烯酰胺的原位光聚合制备了一种透明荧光低共熔凝胶。与甘油和 Zn(NO₃)₂ 水溶液相比，含硝酸

根的低共熔溶剂显著改变了 [H₃DPP]²⁺ 的光物理行为，使其荧光发射发生明显红移且强度显著提升。单体引入对低共熔溶剂调控的发射行为影响极小；尽管凝胶网络形成会造成一定程度的荧光衰减，但低共熔溶剂赋予的发光特征仍基本保留。光谱分析结合 DFT/TD-DFT 计算结果表明，NO₃⁻ 与 [H₃DPP]²⁺ 上质子化吡啶 N-H 位点、吡咯 N-H 位点间形成的定向氢键相互作用，可调控其电子结构与光学跃迁过程。所得低共熔凝胶兼具高可见光

透明度、230 kPa 拉伸强度、820% 断裂伸长率，对多种基材具有良好黏附性（在聚四氟乙烯 PTFE 表面黏附强度达 0.25 MPa），且溶剂保持能力优异：70 °C 下储存 9 天后溶剂保留率仍可达 95%。此外，该凝胶在 25、70 和 -25 °C 下长期储存后，仍可保持稳定的荧光发射。基于其高透明度、良好力学性能与刺激响应荧光特性，该低共熔凝胶可实现局部化学书写、紫外光触发可视化及条形码数字读取功能。

本研究表明，低共熔溶剂调控的

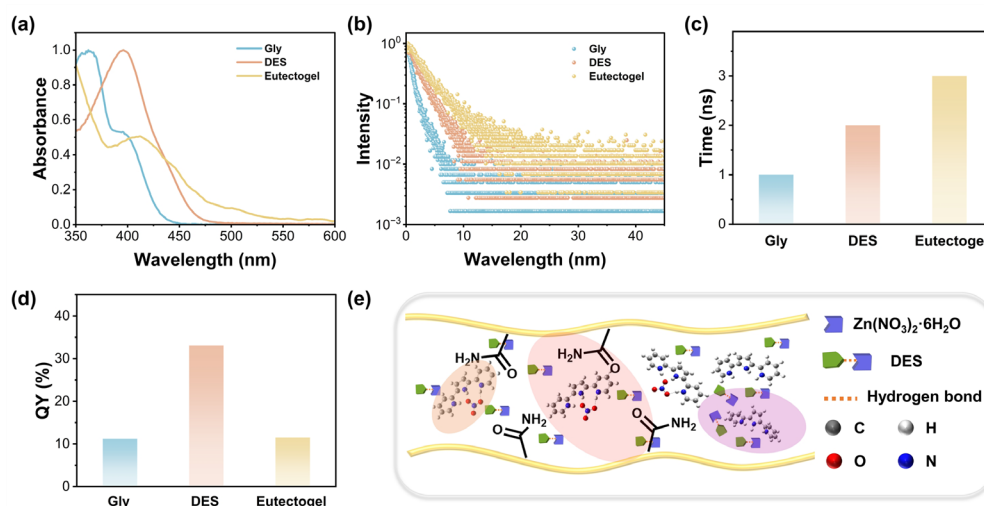


图 1. $[\text{H}_3\text{DPP}]^{2+}$ 的微环境依赖光物理行为及其相互作用分析。

Figure 1. Microenvironment-dependent photophysical behavior and interaction analysis of $[\text{H}_3\text{DPP}]^{2+}$.

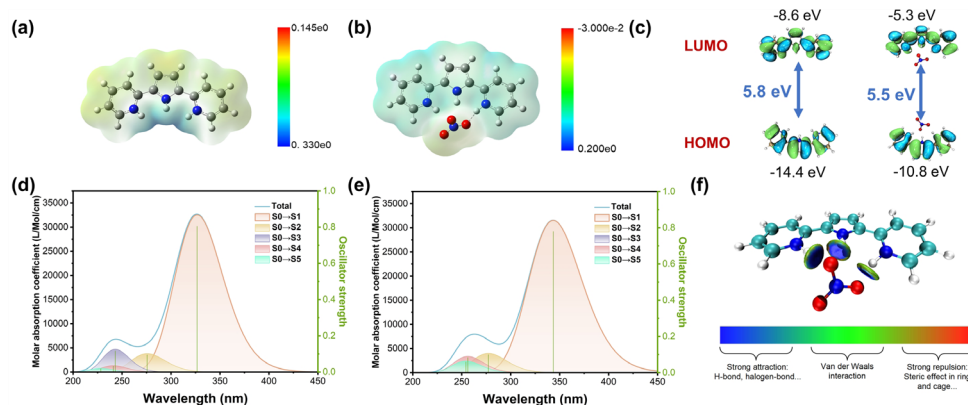


图 2. $[\text{H}_3\text{DPP}]^{2+}$ 与 NO_3^- 相互作用的理论计算。

Figure 2. Theoretical calculations for the interaction between $[\text{H}_3\text{DPP}]^{2+}$ and NO_3^- .

微环境为分子发射行为调控，以及面向可视化防伪、信息加密领域的稳定刺激响应型荧光软材料开发提供了有效策略。

第一作者：陕西师范大学博士研究生董欢欢、苟欣瑜

通讯作者：陕西师范大学房喻教授、彭军霞教授

全文链接：<https://doi.org/10.1021/acs.jpcc.6c04332>

Fluorescent eutectogels, as emerging smart materials that integrate the unique microenvironment, excellent temperature resistance, and eco-friendliness of deep eutectic solvents (DESs), have driven remarkable advancement in flexible

optical materials and information encryption.

Here we report a transparent fluorescent eutectogel prepared by incorporating the environmentally sensitive cationic luminophore 2,5-bis(2-pyridiniumyl)-1H-pyrrole bis(hexafluorophosphate) ($[\text{H}_3\text{DPP}]^{2+}$) into a glycerol/ $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ DES followed by in situ photopolymerization of acrylamide. The nitrate-containing DES strongly reshapes the photophysical behavior of $[\text{H}_3\text{DPP}]^{2+}$, producing a pronounced red shift and enhanced emission relative to glycerol or aqueous $\text{Zn}(\text{NO}_3)_2$ solution. The addition of monomer has little influence on the

DES-regulated emission, whereas gel-network formation causes only moderate fluorescence attenuation while largely preserving the DES-defined emissive state. Spectroscopic analysis and DFT/TD-DFT calculations indicate that directional hydrogen-bonding interactions between NO_3^- and the protonated/pyrrolic N-H sites of $[\text{H}_3\text{DPP}]^{2+}$ modulate its electronic structure and optical transitions. The resulting eutectogel exhibits high visible transparency, tensile strength of 230 kPa, stretchability of 820%, adhesion to diverse substrates (0.25 MPa on PTFE), and excellent solvent retention, maintaining 95% of its solvent after storage at 70 °C for 9 days. The fluorescence also remains

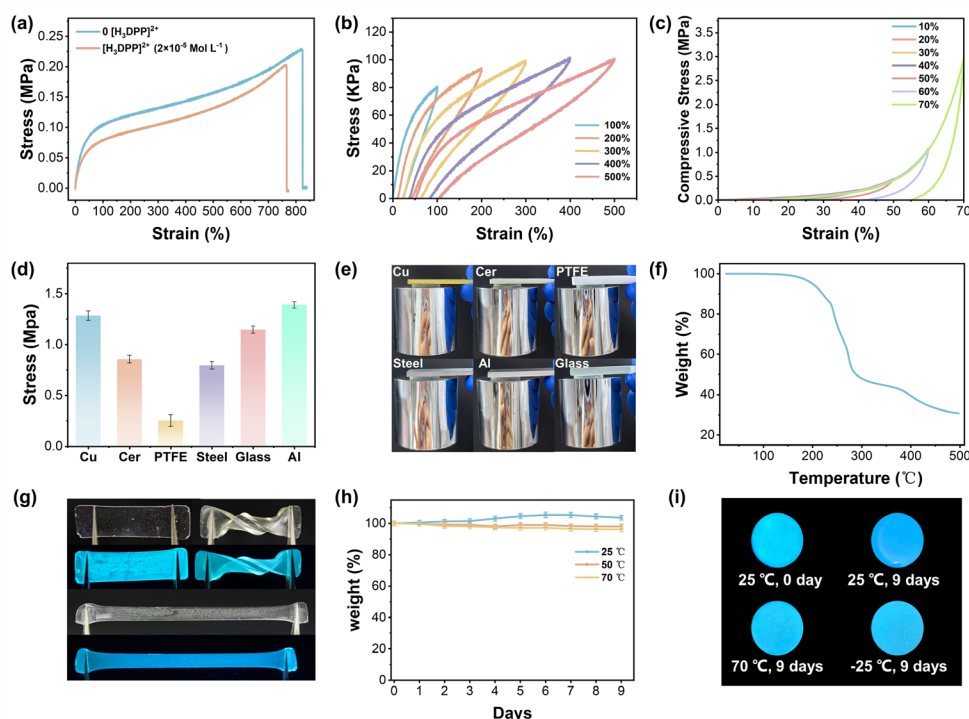


图 3. $[\text{H}_3\text{DPP}]^{2+}$ 掺杂低共熔凝胶的力学性能、热稳定性及环境稳定性。

Figure 3. Mechanical properties, thermal stability, and environmental stability of the $[\text{H}_3\text{DPP}]^{2+}$ -doped eutectogel.

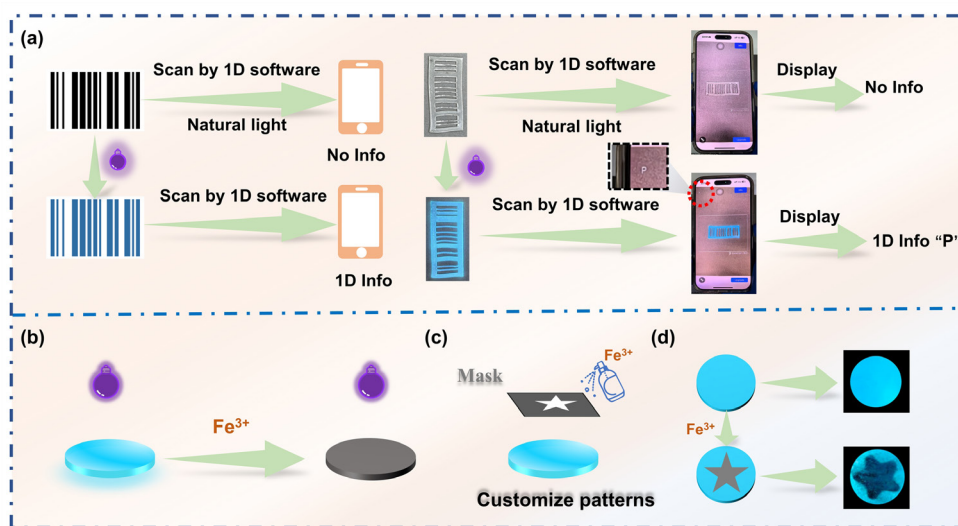


图 4. 基于 Fe^{3+} 诱导 $[\text{H}_3\text{DPP}]^{2+}$ 掺杂低共熔凝胶荧光猝灭的信息写入、可视化与数字化读取。

Figure 4. Information writing, visualization, and digital readout based on Fe^{3+} -induced fluorescence quenching of the $[\text{H}_3\text{DPP}]^{2+}$ -doped eutectogel.

visible after prolonged storage at 25, 70, and -25 °C. Moreover, relying on the high transparency, good mechanical properties and stimulus-responsive fluorescence characteristics of this eutectogel, localized chemical writing, UV-triggered visualization and barcode digital reading can be realized.

This work demonstrates that DES-regulated microenvironments offer a robust platform for tuning molecular emission and developing stable, stimulus-responsive fluorescent soft materials for visual anti-counterfeiting and information encryption.

First Authors: Dong Huanhuan and Gou Xinyu, doctoral candidate, Shaanxi Normal University

Correspondence Authors: Prof. Fang Yu and Prof. Peng Junxia, Shaanxi Normal University
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Heterostructural Cyano-Functionalized Nanofilm Sensors via Interfacially Confined Dynamic Condensation toward High-Performance Hydrazine Vapor Detection

Jianyu Tuo, Yong Chen, Kaixiang Cui, Ruijuan Wen, Taihong Liu,* Liping Ding,* and Yu Fang



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基于界面限域动态缩合策略构建的异质结构氰基功能化纳米膜传感器用于高性能肼蒸气检测

Jianyu Tuo, Yong Chen, Kaixiang Cui, Ruijuan Wen, Taihong Liu,* Liping Ding,* and Yu Fang. <https://doi.org/10.1021/acs.analchem.6c03767>

界面自组装纳米膜是一类超薄的功能型材料，在分离、催化、储能、环境修复以及化学传感等诸多领域具有重要应用价值。该类材料优势源于界面反应的限域效应，纳米尺度的厚度调控、连续完整的结构特征，以及高度可变的界面微环境，其性能优于传统块体膜或涂层膜。然而，现有界面纳米膜体系多选用高度对称、各向同性的构筑单元，在交联反应中易生成结构均一的共价网络。多数情况下，这类均质网络会导致膜内电荷分布、界面极性与分子堆积模式缺乏空间差异化，在一定程度上限制了定向传质通道、异质吸附位点以及各向异性功能界面的形成。因此，借助不对称分子设计对构筑单元进行定向修饰，为突破传统对称纳米膜的性能瓶颈、拓宽其结构-功能调控空间提供了直接有效的策略。

本研究设计并合成了一种不对称构筑单元 CNHA，该分子同时含有酰肼与氰基两种不同的官能团。通过将

酰肼缩合与克脑文格尔缩合反应相结合，使其与四苯乙烯四醛在界面限域动态缩聚条件下完成成膜过程，并于共价网络内同步构建动态 C=N 键与共轭 C=C 键。所制备的 TFPE-CN 纳米膜兼具自支撑特性与均匀无缺陷的形貌；其异质键合结构可有效促进 π 电子离域、增强分子内电荷转移效应，使材料实现 30.8% 的荧光量子产率与

185 nm 的斯托克斯位移。该薄膜依托氢键相互作用与特异性化学反应的协同机制实现对肼蒸气的灵敏检测。此外，以 TFPE-CN 纳米膜为核心传感单元搭建的薄膜基荧光传感平台，可实现 N_2H_4 蒸气的实时原位检测，具备超高的灵敏度（检出限约为 130 ppt）、快速响应以及优异的选择性。在实际检测场景中，该传感薄膜亦可通过显

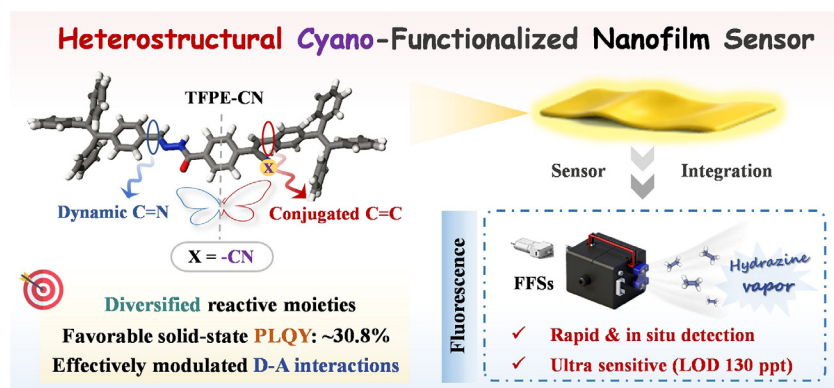


图 1. 氰基功能化纳米膜的异质结构及肼蒸气传感应用示意图

Figure 1. Schematic illustration of the heterostructural cyano-functionalized nanofilm for hydrazine vapor sensing

著的荧光颜色变化,实现对肼蒸气的裸眼识别。本研究提出了一种用于制备界面纳米薄膜的不对称分子设计策略,为开发高性能、便携式肼蒸气传感平台奠定了基础。

第一作者: 陕西师范大学硕士研究生拓建宇
通讯作者: 陕西师范大学丁立平教授、刘太宏教授

全文链接: <https://doi.org/10.1021/acs.analchem.6c03767>

Interfacially self-assembled nanofilms represent a class of ultrathin functional materials that underpin a wide range of applications, including separation, catalysis, energy storage, environmental remediation, and chemical sensing. Their appeal originates from the intrinsic confinement of interfacial reactions, which enables nanoscale thickness control, structural continuity, and a highly tunable interfacial microenvironment, conferring distinct advantages over conventional bulk membranes or coatings. Nevertheless, the majority of interfacially assembled nanofilms are still constructed from highly symmetric or isotropically distributed building blocks, which favor ordered packing and structural continuity but often generate chemically homogeneous networks. In the majority of cases, such uniform architectures provide limited spatial differentiation in charge distribution, interfacial polarity, and molecular stacking, which to a certain extent restrict the formation of directional transport pathways, heterogeneous adsorption sites, and anisotropic interfacial responses. Encoding molecular asymmetry into the building blocks therefore represents a direct and powerful strategy to overcome the intrinsic limitations of conventional symmetric nanofilms and to expand their structure-function tunability.

This study prepared an asymmetric building block CNHA featuring two different functional groups of acylhydrazide and cyanomethyl. By combining the acylhydrazone condensation and Knoevenagel condensation reactions, the film-

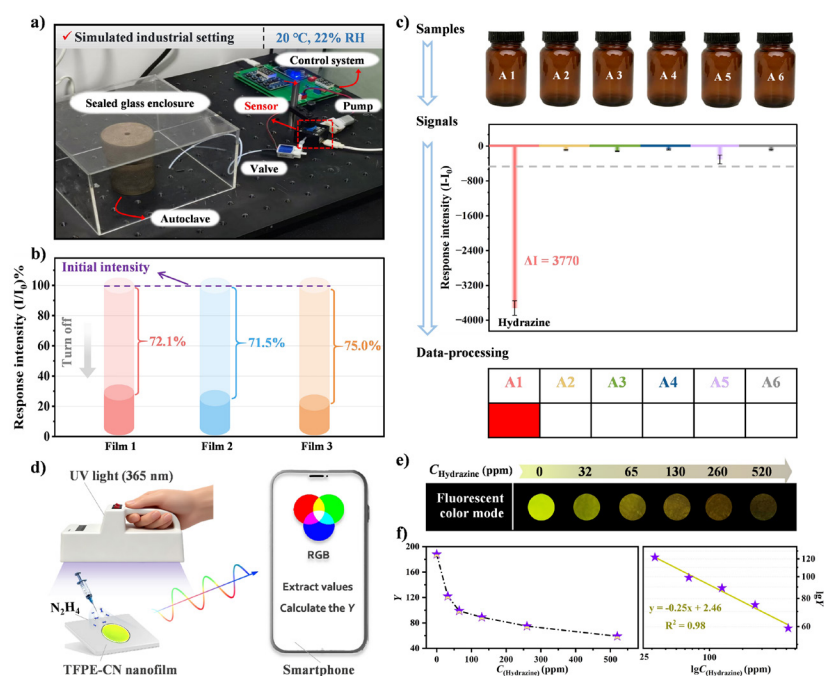


图 2. (a) 模拟肼溶液实际挥发场景的测试环境示意图; (b) 该测试环境下纳米膜对肼蒸气的荧光响应; (c) 用于评估纳米膜肼检测性能的双盲测试; (d) 在 365 nm 紫外灯照射下, 利用智能手机采集纳米膜荧光图像, 提取 RGB 值并计算相应 Y (灰度) 值; (e) 暴露于不同浓度肼蒸气下的纳米膜的荧光图像; (f) 基于拟合方程及 Y 值实现肼蒸气浓度的定量分析。

Figure 2. (a) Test environment simulating the real scenario of N_2H_4 volatilization; (b) Fluorescence response of the nanofilms to N_2H_4 vapor in the test environment; (c) Double-blind field tests for evaluating the performance of the nanofilms for N_2H_4 detection; (d) Smartphone-based image capture of the nanofilms under UV light followed by RGB values extraction and Y values calculation; (e) Fluorescence images of the nanofilms after exposure to different concentrations of N_2H_4 . (f) Y analysis to quantify N_2H_4 based on the fitted calibration equation.

forming process is completed with tetraphenylethylene tetraaldehyde under the interfacially confined conditions, and dynamic C=N bonds and conjugated C=C bonds are also synchronously constructed within the covalent network. The as-prepared TFPE-CN nanofilms exhibited excellent physical properties including structural robustness, flexibility, and uniform morphology, while the heterostructural linkage promoted π -electron delocalization and strengthened intramolecular charge transfer, leading to a favorable PLQY of 30.8% and a pronounced Stokes' shift of 185 nm. The TFPE-CN nanofilms achieved critical detection of N_2H_4 vapor through synergistic interaction of hydrogen bonding and the generated new adduct. Integrated into a home-built portable sensing platform, the TFPE-CN nanofilm

enables real-time, in situ detection of N_2H_4 vapor, delivering ultrahigh sensitivity (detection limit ≈ 130 ppt), rapid response, excellent selectivity, and robust stability. In practical detection scenarios, the nanofilm also enables naked-eye recognition of N_2H_4 vapor through distinct fluorescence color changes. This work offers an asymmetric molecular engineering strategy for fabricating interfacial nanofilms and lays a foundation for developing high-performance and portable sensing platforms for N_2H_4 vapor.

First Author: Tuo Jianyu, master's student, Shaanxi Normal University
Correspondence Authors: Prof. Ding Liping, Prof. Liu Taihong, Shaanxi Normal University
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Lysosome-Targeted Iridium(III) Photosensitizers Activate the Mitophagy–Ferroptosis Axis to Boost Two-Photon Photoimmunotherapy Against Hypoxic Cisplatin-Resistant Tumors

Hui Jiang, Qiaoshan Lie, Fa Wang, Shufei Li, Jinrong Yang, Wanhe Wang,* Taihong Liu,* Johannes Karges,* and Hui Chao*

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双核铱光敏剂联动线粒体自噬与铁死亡增强双光子光免疫治疗

Hui Jiang, Qiaoshan Lie, Fa Wang, Shufei Li, Jinrong Yang, Wanhe Wang,* Taihong Liu,* Johannes Karges,* and Hui Chao*. J. Med. Chem., 2026. <https://doi.org/10.1021/acs.jmedchem.6c02622>

本文报道了一种溶酶体靶向双核铱(III)光敏剂 Ir₂-pbt-877, 该光敏剂可在 810 nm 近红外双光子激发下发挥光动力作用, 在缺氧条件下仍能产生 I 型活性氧, 并通过溶酶体与线粒体之间的应激传递, 促进顺铂耐药肺癌细胞发生铁死亡。

针对肿瘤缺氧环境对光动力疗法(PDT)的限制, 研究团队结合 π 共轭扩展与双核化设计, 构建并筛选了一系列铱(III)配合物。其中, Ir₂-pbt-877 的单线态氧量子产率达到 0.81, 最大双光子吸收截面位于 810 nm, 且暗细胞毒性较低。缺氧条件下, 其单线态氧生成受到抑制, 但仍可产生超氧阴离子自由基, 为低氧环境中的光动力治疗提供了基础。机制研究表明, 光活化后的 Ir₂-pbt-877 引发溶酶体膜通透性增加、组织蛋白酶 B 释放和钙稳态失衡, 继而伴随线粒体膜电位下降及 PINK1 相关线粒体自噬。

与此同时, 细胞内谷胱甘肽(GSH)耗竭、谷胱甘肽过氧化物酶 4(GPX4)表达下调、亚铁离子积累和脂质过氧化增强。结合抑制剂救援实验, 这些结果支持线粒体自噬与铁死亡在光动力损伤过程中存在功能联系, 并伴随免疫原性危险信号的释放或暴露。

在 CMT167 小鼠序贯对侧肿瘤再挑战模型中, 研究团队使用 PEG 纳米制剂 Ir₂-pbt-877@PEG 并对原发肿瘤进行局部双光子照射, 不仅抑制了原发肿瘤生长, 还延缓了治疗后第 7 天再次接种、未经照射的对侧肿瘤生长。上述效应伴随树突状细胞成熟、CD8⁺ T 细胞浸润增加和调节性 T 细胞减少, 提示局部光动力治疗可引发系统性抗肿瘤免疫应答。该研究为耐缺氧金属光敏剂的设计, 以及光动力治疗与铁死亡相关免疫激活的结合提供了实验依据。

第一作者: 暨南大学和中山大学博士研究生江荟

通讯作者: 暨南大学王万河教授、陕西师范大学刘太宏教授、德国波鸿鲁尔大学 Johannes Karges 教授、暨南大学和中山大学巢晖教授

全文链接: <https://doi.org/10.1021/acs.jmedchem.6c02622>

A collaborative team from Jinan University, Sun Yat-Sen University, Shaanxi Normal University, and Ruhr University Bochum has reported a lysosome-targeted dinuclear iridium(III) photosensitizer, Ir₂-pbt-877, in the Journal of Medicinal Chemistry. The complex combines near-infrared two-photon activation with type-I reactive oxygen species generation under hypoxia and links organelle stress to ferroptosis and antitumor immune activation.

By combining π -conjugation extension with dinuclearization, the researchers identified Ir₂-pbt-877 as a lead

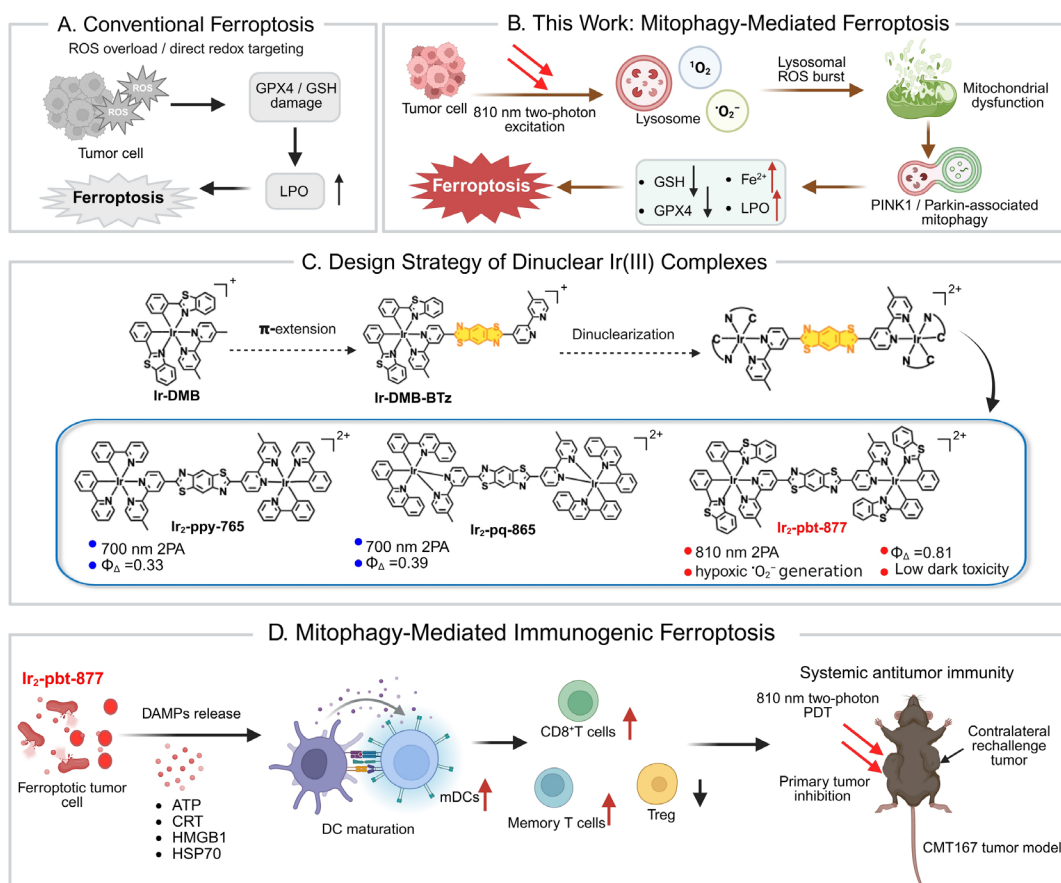


图 1. 双核铱 (III) 光敏剂的分子设计、溶酶体—线粒体应激传递及线粒体自噬相关铁死亡与抗肿瘤免疫激活机制
Figure 1. Molecular design and proposed action mechanism of the lysosome-targeted dinuclear iridium(III) photosensitizer Ir₂-Pbt-877

compound with a singlet-oxygen quantum yield of 0.81, a maximum two-photon absorption cross section at 810 nm, and low dark cytotoxicity. Under hypoxia, singlet-oxygen generation was suppressed, whereas superoxide generation remained detectable, supporting a hypoxia-tolerant type-I photodynamic pathway.

In cisplatin-resistant A549R lung cancer cells, photoactivation induced lysosomal membrane permeabilization, cathepsin B release, calcium dysregulation, mitochondrial depolarization, and PINK1-associated mitophagy. These changes were accompanied by GSH depletion, reduced GPX4 expression, Fe(II) accumulation,

and enhanced lipid peroxidation. Inhibitor-rescue experiments supported a functional connection between mitophagy and ferroptosis, together with the release or exposure of immunogenic danger signals.

In a sequential contralateral CMT167 rechallange model in mice, the PEG-based nanoformulation Ir₂-pbt-877@PEG, combined with local two-photon irradiation, suppressed primary tumor growth and delayed the growth of a non-irradiated contralateral tumor implanted seven days after treatment. Increased dendritic-cell maturation and CD8⁺ T-cell infiltration, together with fewer regulatory T cells, supported systemic antitumor immune activation.

These preclinical findings provide a basis for developing hypoxia-tolerant metal-based photosensitizers that connect photodynamic therapy with ferroptosis-associated immune responses.

First Author: Jiang Hui, doctoral candidate, Jinan University and Sun Yat-Sen University
Correspondence Authors: Prof. Wang Wanhe, Jinan University; Prof. Liu Taihong, Shaanxi Normal University; Prof. Johannes Karges, Ruhr University Bochum; Prof. Chao Hui, Jinan University and Sun Yat-Sen University
Full Text Link: <https://doi.org/10.1021/acs.jmedchem.6c02622>

人工智能赋能基础教育阶段化学教育的边界和路径

——课堂教学、实验教学、评价体系和教师教育的系统性重构

房喻

(西部高校化学专业(师范)虚拟教研室(教育部))

陕西师范大学化学化工学院 陕西西安 710119)

自2022年底ChatGPT发布以来,人工智能(AI)对教育的冲击迅速从“未来命题”演变为“现实挑战”。短短数年间,各类AI辅助教学工具层出不穷,从个性化学习路径规划到智能作业批改,从虚拟实验模拟到知识图谱构建,技术向基础教育的渗透速度远超预期。2024年末,美国亚利桑那州特许学校委员会批准开办一所全新特许在线学校Unbound Academy^[1]。从2025年秋季起,该校四至八年级学生每天的文化课由AI在两小时内完成,其余四小时用于教师辅导、项目式学习及公众演讲、金融素养等工作坊,以强化批判性思维与综合能力培养。这一探索虽有争议,却昭示了一个不可回避的趋势:当AI能以极高效率完成知识传授时,基础教育的课堂形态与教师角色必将面临重构。

2025年1月,中共中央、国务院印发的《教育强国建设规划纲要(2024—2035年)》明确提出“促进人工智能助力教育变革”^[2]。化学学科因其独特性,在这场变革中面临的挑战尤为突出。化学教育不仅要帮助学生建立从原子、分子到化学键的微观认知框架,更需通过学科特有的思维方式培育科学精神与理性态度。目前,AI尚难以替代培养科学精神和理性态度的深层教学,但如果教师不主动转型,就可能在效率至上的技术浪潮中被边缘化。本文将从AI给基础化学教学带来的挑战、必须直面的深层次问题以及教师培养与持续发展三个维度

展开讨论,并在此基础上提出建议。

1 AI给基础化学教学带来的挑战

1.1 AI赋能学习的高效与局限

2023年末,为系统了解毫米波通信与太赫兹探测技术,笔者借助ChatGPT-4进行了三个多小时的集中学习^[3]。经过三十余轮问题迭代,应笔者要求,它将整个交互内容按“毫米波通信”与“太赫兹技术”两个板块,分别归纳整理为两份结构清晰、内容充实的PPT文稿。整个过程效率之高、针对性之强,远超预期。但笔者也发现,如果提问不够精准、不够深入,迭代不充分,它很容易给出笼统甚至失真的回答。这次经历使笔者确信:AI赋能的学习效率极高,但“学会学习”已成为前提。如果学生不具备精准提问和批判性审视的能力,AI不仅难以提供有效助力,反而可能使其在错误认知上越走越远。

1.2 AI进课堂的边界与路径

AI能够实现个性化教学、动态可视化 and 精准学情诊断,这些都是传统课堂难以企及的。然而,效率的提升并不等同于教育质量的改善。当一位初中生通过AI在三分钟内“学会”了质量守恒定律,背下表述并做对选择题时,他真的理解了吗?化学概念教学有其特殊性。质量守恒定律的发现是拉瓦锡推翻燃素说的经典案例[4],这一过程中蕴含的科学精神与方法论,远重于定律的文字表述。如果AI教学只提取“考点”而远离“故事”,只

输出结论而省略探究过程,学生得到的不过是知识的躯壳,而非科学思想的血脉。

笔者了解到的一位初中化学教师的实践案例,为AI辅助课堂教学提供了有价值的实证参照。在“质量守恒定律”单元中,该教师借助AI支持学生课前完成基本概念的自主学习,课堂时间不再用于常规讲授,而是聚焦于核心认知冲突问题,亦即“镁条燃烧后质量为何增加”的深度研讨。教学效果表明,学生在概念理解的深刻性和问题迁移能力上均显著优于传统讲授式班级。该案例的关键启示在于:教师将AI释放出的课堂时间全部转化为探究性对话与批判性思维训练,而非引导学生机械复看AI讲解并叠加习题训练。后者本质上仅替换了信息传递的载体,且替换为一种缺乏教学互动与情感支持的“冷媒介”。由此可见,AI在化学课堂中的角色定位,应是促进学生认知拓展的学习工具,而非压缩思考过程的数字讲授终端。

在AI赋能条件下,化学实验教学的地位非但不能削弱,反而应当加强。实验教学承载着理论教学无法替代的功能:学生通过亲手操作获得颜色变化、温度变化、气体产生和沉淀生成等感官体验,这是任何虚拟模拟都无法完全替代的。实验过程中因操作偏差导致的异常结果、偶然现象引发的新问题等不确定性,恰恰可能成为培养学生仔细观察、深入分析和灵活应变能力的契机。动手实验还能让

学生亲历科学探究全过程,进而理解科学知识的实践来源,这更是虚拟场景难以替代的。当然,AI可以在实验教学中发挥辅助作用:通过虚拟仿真帮助学生预习操作流程、理解实验原理;借助智能分析辅助解读实验数据、诊断操作问题;利用安全预警防范危险操作。但AI无法替代真实的实验操作。此外,化学实验常需分组合作完成,这一过程有助于培养学生的合作意识、责任感和规范意识,同样是AI无法提供的教育价值。因此,AI赋能实验教学的正确方向,是用AI辅助增强实验教学效果,而非以虚拟替代真实。

1.3 AI时代的必备素养:学会学习

“学会学习”是AI时代最核心的能力,但在基础教育中远未被充分重视。在信息稀缺的时代,教育的核心任务是帮助学生“获得知识”;在AI时代,知识获取空前便利,教育的核心任务必须转向帮助学生“学会如何学习”。基于笔者使用ChatGPT-4的学习体验,“学会学习”至少涵盖四个层面:其一,明晰自身需求,准确界定知识边界;其二,将需求凝练为精准问题,提问愈精准、迭代愈深入,AI的回应愈具价值;其三,对AI输出保持批判性审视,其科学性与可信度须由使用者独立研判,而化学作为实证科学,实验验证始终是不可替代的鉴别手段;其四,善用AI将碎片化知识结构化,整合为系统的认知框架。

笔者在研究生培养中的实践也印证了这一点。自2013年起,笔者要求报考的所有硕士和博士新生必须选修一门国际名校开设的传感器或分子材料相关MOOC课程并通过考试。十余年来,每届学生都感到“特别困难”,但最终都坚持了下来。他们的收获不仅是专业知识和英语能力的提升,更是视野的拓展与自信的增强。这使笔者深切认识到,引导学生达到能够独立获取知识的状态,远比教给他们多少具体知识更为重要。这一原则对基础教育同样适用。然而现实是,基础

教育阶段的学生普遍缺乏自主学习的训练和习惯,而“学会学习”恰恰是AI时代最需从小培养的核心素养。本年度菲尔兹奖获得者之一、数学家王虹的成长经历也印证了这一点。据报道,她自幼便养成了自主学习的习惯,这种能力贯穿其学术生涯,成为她取得杰出成就的重要基础^[5]。

2 必须直面的三个深层次问题

2.1 教师角色的重新定位

教师角色必须重新定义,但“转型”不等于“退场”。当知识传授可大量交由AI完成时,教师的独特价值在于价值引领、情感陪伴和思维激发。具体到化学教学中,在AI完成元素、原子、分子、原子结构、化学键和反应速率等基础知识的讲授后,一位优秀的化学教师还应引导学生在掌握基本概念的基础上深入思考:门捷列夫为何能预言未知元素?科学发现的思维方式是什么?芯片材料、新能源电池、生物医药、特种功能材料,乃至“双碳”目标下的绿色合成与催化转化等,化学如何支撑这些关乎国家战略、人类文明可持续发展和民生福祉的关键领域?科学研究与社会责任的关系如何?这样的教学已超越知识传授,进入思维训练与价值引领的层面。

近期,李希涓、朱玉军、王磊三位学者联合发文^[6]指出,以AI为代表的新技术正深刻变革科学研究范式、社会运行模式与知识生产形态,对教育目标、育人模式及学科发展提出系统性重构要求。在这场变革中,基础教育首当其冲,这一阶段正是学生世界观、人生观、价值观形成的关键时期。化学教育承载着独特育人价值:既传授物质变化的相关知识,又依托学科特有思维方式,培养学生的科学精神、理性态度与求真品格。这类素养正是AI难以替代的,亦是AI时代教师必须坚守的核心阵地。但也应当看到,倘若教师不主动转型,不从重复性知识讲授中抽身,聚焦更高价值的教育

活动,那么AI替代教师将不再只是技术层面的假设,而只是时间问题。

2.2 评价体系的系统重构

评价体系的失灵是AI带来的最深层次挑战。如果学生借助AI能轻松完成作业和测试,考试分数还能反映真实的学习成果吗?如果知识获取变得如此便利,记忆性和复现性的考核还有多大意义?问题不在于“要不要禁止学生用AI”,而在于“什么才是值得评价的”,是记住了多少反应方程式,还是能够设计实验方案解决一个实际问题?是会背诵概念定义,还是能够运用化学原理分析社会议题?这要求评价重心从“考查知识记忆”转向“考查能力素养”,从“终结性评价”转向“过程性评价”,从“单一维度”转向“多维指标”。已有教师尝试“人机协同”的评价模式:允许学生在完成开放性任务时使用AI工具,但必须标注AI的贡献与自己的独立思考,评价重点放在问题分析、方案设计和批判性反思上。

教师评价同样面临挑战。如果知识传授主要由AI完成,再以学生考试成绩评价教师,不仅不公平,也失去了学理基础。我们需要探索新的教师评价体系,将课程设计能力、学习引导能力、学生发展指导能力等纳入评价范畴。学校管理也需系统性重构:统一的课程进度是否仍为必需?班级授课制是否还是唯一的组织形式?当个性化学习成为常态,学分认定、考试制度、教师工作量核算等一系列配套制度均需重新设计。教材建设同样面临转型:纸质教材已不再是知识的主要载体,未来的化学教材或将更多承担学习路线图与问题集的角色。

2.3 AI赋能教育的底线坚守

推进AI赋能教育的过程中,有几条底线必须守住。一是防止思维惰性风险。如果学生习惯于从AI获取现成答案,独立思考能力可能退化。化学的魅力在于探究未知,若学生只被动接受结论,不再追问“为什么”“还

有没有别的可能”，化学教育的灵魂便丢失了。二是警惕数字鸿沟加剧。AI教育资源的获取依赖硬件和网络条件，如果优质资源集中在发达地区和优质学校，城乡之间、区域之间的教育差距可能进一步拉大。三是不偏离教育本质。效率并非教育最重要的目标。价值引领、人格塑造、情感浸润恰恰需要慢下来，需要人与人之间深度的互动。基础教育阶段的学生处于人格形成关键期，他们需要的不仅是高效率的知识输入，更需要有温度的成长环境。四是防止对教师作用的简单化理解。教师最核心的价值正在于AI做不到之处：观察学生的情绪变化，捕捉课堂的意外生成，发现学生的独特之处，帮助学生建立自信。这些难以量化的教育行为，才是教师专业性的真正体现。

3 AI 赋能下的教师培养与持续发展

关于AI赋能基础化学教育的讨论大多聚焦教学层面，但有两个更根本的问题被普遍忽视：师范生培养的滞后和在职教师持续学习的困境。某种意义上，这两个问题比AI工具本身更值得关注，因为它们决定着未来相当长一段时间基础教育阶段化学教育的品质。

3.1 师范生培养的滞后与重构

师范生培养方案的滞后是一种隐性的危机。当前师范院校化学专业的培养方案，总体上仍沿袭“学科知识传授+教育理论研习+教学能力训练+教育实习实践”的基本框架。这一框架在过去是合理的，因为师范生需要储备足够的化学知识才能站上讲台。但在AI能高效传授知识的时代，师范教育的重心是否需要调整？

问题不仅在于专业课程的内容与教学方式，更在于教育教学法课程的严重滞后。当前的教育理论研习和教学能力训练，仍以传统课堂为预设场景，教学设计、课堂组织、学生评价

等核心课程几乎未将AI纳入考量。师范生学习如何设计教学流程、如何提问、如何组织讨论，但很少被引导思考：当AI能即时回答学生的问题时，教师的提问策略应该如何调整？当每个学生拥有个性化AI学伴时，班级讨论的基础和方式将发生怎样的变化？当AI能够自动完成作业批改时，评价的功能和形式又该如何重新定义？这些不是学科知识的问题，而是教学法本身需要重构的问题。

学科知识的储备同样需要重新审视。师范生仍需具备扎实的化学学科基础，但“扎实”的内涵正在发生变化。过去，“扎实”意味着记忆大量的事实、公式和反应，能够随时调用；在未来，“扎实”更多地意味着对学科核心概念和思想方法的深刻理解，能够判断AI生成内容的准确性，能够将抽象原理转化为学生可感知的问题情境。那些AI可以随时提供的具体知识细节，未必需要占用师范生宝贵的记忆空间；而那些AI无法替代的学科洞察力和判断力，恰恰需要加倍强化。

教学法内容的改革比专业课程调整更为紧迫。化学教学法课程需要系统更新：如何在AI辅助环境下进行学情诊断？如何利用AI支持分层教学和个性化指导？如何设计人机协同的探究性学习任务？如何引导学生批判性地审视AI给出的答案？这些内容应当成为新一代师范生教学能力训练的核心模块。如果教学法课程本身不革新，师范生将带着旧工具箱走进新课堂，这正是未来几年最值得警惕的危机。

师范生培养的调整不能止于增加一两门“AI工具使用”的选修课，而需要更为系统的设计。首先，应让师范生以学习者身份深度体验AI辅助学习的过程，正如笔者跟随ChatGPT-4学习毫米波通信和太赫兹探测那样。唯有亲身经历“提问—应答—追问”的迭代过程，体会AI的优势与局限，他们才能在未来教学中有效指导学生。其次，需培养师范生在AI辅助环境下

的教学设计能力：何时让学生直接向AI提问，何时组织面对面讨论，何时需要教师亲自讲解，这些判断需要在实践中积累经验。再次，要训练师范生在AI辅助环境下的课堂组织能力：当每个学生面对不同的AI学习进度时，教师如何协调全班的教学节奏？如何确保课堂讨论依然有效？如何关注到每一位学生的学习状态？这些问题在传统教学法课程中几乎未被涉及。

更为根本的是，师范教育需要重新思考化学教师的核心素养。在未来，一位优秀的化学教师或许不再需要记住所有反应方程式（因为AI可随时提供），但必须能够设计出激发学生探究欲望的学习场景；必须能够识别学生在AI学习过程中产生的困惑并给予有效引导；必须能够在学生接触了大量AI生成的信息后，帮助他们建立批判性思维和科学判断力。这些素养的培养，需要师范教育课程体系的系统性调整，而非零散地修补。师范教育的惯性十分强大，培养方案的调整需要周期，但AI的普及速度不会等待。

3.2 在职教师持续学习的困境与出路

在职教师持续学习的困境是眼前的危机。当前在职的数十万基础教育化学教师，大多成长于“以教师为中心、以知识传授为核心”的传统教育模式。他们中的许多人虽然对AI有所耳闻，但缺乏系统的学习和实践。一个常见的现象是：学校引入AI教学平台，教师参加培训掌握了基本操作，但回到课堂后依然沿用原来的教学方式，AI仅仅被当作偶尔使用的“辅助工具”，其潜力远未被挖掘。这种情况的出现并非教师不努力，而是AI赋能教育所带来的变革涉及教学的每一个环节，仅仅培训操作技能远远不够。教师需要重新理解自己的角色定位，重新设计课程结构，重新思考评价方式，而这些都难以通过浅层培训解决。更令人担忧的是，一些学校在推动AI教学时，对教师的要求仅仅是“用起来就行”，却缺乏系统的制度跟进，没有

提供持续的学术支持,也没有组建必要的学习共同体。

目前面向教师的 AI 培训大多停留在“功能介绍+操作演示”层面,与实际教学场景脱节。教师需要的不是泛泛的了解,而是针对化学学科特点的具体指导。例如,如何用 AI 讲解原子结构?如何用 AI 设计分层作业?如何用 AI 辅助实验教学?如何识别 AI 给出的错误信息?这些才是教师真正需要掌握的实操性知识。

建立教师学习共同体是一条可行的路径。当同一所学校或同一区域内的教师形成学习共同体,定期分享 AI 辅助教学的尝试、困惑与经验时,个体的探索便汇聚为集体的智慧。一位教师发现用 AI 组织“化学与生活”主题讨论效果很好,另一位教师摸索出利用 AI 进行分层作业设计的方法,这些分散的经验通过共同体的交流得以汇聚、验证和推广,远比自上而下的统一培训更具生命力。

4 建议与展望

建议一:重构师范生培养方案,将 AI 素养纳入核心课程。化学师范专业应在保持学科基础扎实的同时,增设 AI 辅助教学设计、人机协同课堂组织等模块,让师范生以学习者身份深度体验 AI 辅助学习,在走上讲台之

前就理解 AI 的优势、局限及其对学习方式的影响。建议教育部师范类专业认证标准中增加 AI 素养相关要求,推动全国师范院校课程体系调整。开展“AI 时代化学教师核心素养”专项研究,为培养方案调整提供学理支撑。同时,师范院校应率先建设 AI 辅助教学的示范课程和案例库,为师范生提供可观摩、可模仿的实践资源。

建议二:建立在职教师持续专业发展的支持体系。教育管理部门应将 AI 素养纳入教师培训必修内容,尤其要重视面向化学等学科的针对性培训,而非泛泛的技术介绍。学校和教研部门应推动教研方式转型,从传统的“听课评课”转向“研究—实践—反思”模式,建立教师学习共同体,让分散的探索汇聚为集体智慧。各级教研活动和教学比赛应及时将 AI 辅助教学能力纳入评价指标,发挥引导作用。尤其要避免两种极端:一是“只用不研”,安装了平台、配备了设备,却缺乏持续的专业支持;二是“不敢用也不会用”,在技术浪潮面前无所适从。建议设立专项资金支持教师开展 AI 辅助教学的行动研究,让教师在实践中成长。

建议三:系统推进评价体系改革。推动学生评价从知识记忆考查转向能力素养考查,将过程性评价、表现性

评价纳入正式框架。探索“人机协同”的评价模式,允许学生在开放性任务中使用 AI,但须标注贡献,评价重点放在问题分析、方案设计和批判性反思上。改革教师评价,将课程设计能力、学习引导能力和学生发展指导能力纳入体系。学校管理层面应重构课程设置和教学安排,降低标准化测试比重,增加开放性任务和实践操作的考核权重。建议教育主管部门组织专家研制 AI 时代化学学科核心素养评价指南,为一线教师和学校提供可操作的参照框架。

化学的基础性、渗透性和支撑性,决定了化学教育质量直接关系到国家科技竞争力的培育,关系到人类文明的可持续发展^[7]。抓住 AI 赋能教育的历史性机遇,对培养具有家国情怀、责任担当和创新能力的时代新人意义重大。但技术终究只是工具,教育的根本在于育人。AI 可以帮助学生更快地获取知识,却无法替代教师在学生心中播下科学精神的种子、点燃求知欲望的火花、引领价值追求的方向。让我们在技术赋能中守护教育本真,在变革创新中锚定育人方向,培养出既能驾驭 AI 工具,又具备独立人格和科学精神的下一代。

没有化学就没有未来, AI 时代的基础化学教育大有可为。

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The Boundaries and Pathways of AI-Empowered Chemistry Education in K-12 Education

—A Systematic Restructuring of Classroom Instruction, Laboratory Instruction, Assessment System, and Teacher Education

Fang Yu

(Virtual Teaching and Research Office for Chemistry (Teacher Education) at Western Universities

(Ministry of Education) School of Chemistry and Chemical Engineering, Shaanxi Normal

University Xi'an, Shaanxi 710119)

Since the release of ChatGPT in late 2022, the impact of artificial intelligence (AI) on education has rapidly evolved from a “future prospect” to a “real-world challenge”. In just a few short years, a wide variety of AI-assisted teaching tools have emerged — ranging from personalized learning path planning to intelligent homework grading, and from virtual experiment simulations to knowledge graph construction — and the pace at which technology is penetrating K-12 education has far exceeded expectations. In late 2024, the Arizona State Board for Charter Schools approved the establishment of a new online charter school, Unbound Academy^[1]. Starting in the fall of 2025, AI will complete the daily academic curriculum for students in grades 4 through 8 within two hours, while the remaining four hours will be dedicated to teacher-led instruction, project-based learning, and workshops on public speaking and financial literacy — all designed to strengthen critical thinking and comprehensive skill development. Although this initiative is controversial, it signals an unavoidable trend: when AI can deliver knowledge with extreme efficiency, the structure of classrooms and the role of teachers in K-12 education will inevitably undergo a transformation.

In January 2025, the “Outline of the Plan for Building a Leading Country in Education (2024–2035),” issued by the Central Committee of the Communist

Party of China and the State Council, explicitly called for “promoting the use of artificial intelligence to drive educational transformation”^[2]. Due to its unique nature, the discipline of chemistry faces particularly significant challenges in this transformation. Chemistry education must not only help students establish a microscopic cognitive framework ranging from atoms and molecules to chemical bonds but also cultivate a scientific spirit and rational attitude through the discipline’s distinctive modes of thinking. Currently, AI is still unable to replace the in-depth teaching required to cultivate a scientific spirit and a rational attitude; however, if teachers do not proactively adapt, they risk being marginalized in a technological wave that prioritizes efficiency above all else. This article will explore three dimensions — the challenges AI poses to basic chemistry education, the deep-seated issues that must be addressed, and teacher training and professional development — and offer recommendations based on this analysis.

1 Challenges Posed by AI to Basic Chemistry Education

1.1 The Efficiency and Limitations of AI-Enhanced Learning

At the end of 2023, to gain a systematic understanding of millimeter-wave communication and terahertz detection technologies, the author

conducted more than three hours of intensive study using ChatGPT-4^[3]. After more than thirty rounds of iterative questioning, and at the author’s request, it organized the entire interaction into two clearly structured and substantive PowerPoint presentations, categorized under the sections “Millimeter-Wave Communication” and “Terahertz Technology”. The efficiency and precision of the entire process far exceeded expectations. However, I also discovered that if questions were not precise or in-depth enough, or if the iterative process was insufficient, the AI was prone to providing vague or even inaccurate answers. This experience has convinced me that while AI-enhanced learning is highly efficient, “learning how to learn” has become a prerequisite. If students lack the ability to ask precise questions and engage in critical analysis, AI will not only fail to provide effective support but may actually lead them further down the path of misconceptions.

1.2 The Boundaries and Pathways for Bringing AI into the Classroom

AI can enable personalized instruction, dynamic visualization, and precise assessment of student progress — all of which are difficult for traditional classrooms to achieve. However, increased efficiency does not necessarily equate to improved educational quality. When a middle school student “learns” the law of conservation of mass in three minutes with the help of AI, memorizes

the statement, and answers multiple-choice questions correctly, does he truly understand it? The teaching of chemical concepts has its own unique characteristics. The discovery of the law of conservation of mass is a classic example of how Lavoisier refuted the phlogiston theory^[4]; the scientific spirit and methodology embedded in this process are far more significant than the literal wording of the law itself. If AI-driven instruction focuses solely on “test points” while neglecting the “story” behind them, and merely outputs conclusions while omitting the process of inquiry, students will gain nothing more than the empty shell of knowledge — rather than the lifeblood of scientific thought.

A practical case study involving a middle school chemistry teacher that the author encountered provides valuable empirical evidence for AI-assisted classroom instruction. In the “Law of Conservation of Mass” unit, the teacher used AI to support students’ independent learning of basic concepts before class. Classroom time was no longer devoted to conventional lecturing but was instead focused on a core cognitive conflict — namely, an in-depth discussion of the question, “Why does the mass of a magnesium rod increase after combustion?” The teaching outcomes showed that students significantly outperformed those in traditional lecture-based classes in both the depth of their conceptual understanding and their ability to apply concepts to new problems. The key insight from this case is that the teacher converted all the classroom time freed up by AI into inquiry-based dialogue and critical thinking training, rather than guiding students to mechanically rewatch AI explanations and simply add more practice exercises. The latter approach essentially merely replaces the medium through which information is conveyed with a “cold medium” that lacks pedagogical interaction and emotional support. It is therefore evident that the role of AI in chemistry classrooms should

be that of a learning tool that facilitates the expansion of students’ cognitive horizons, rather than a digital lecture platform that compresses the thinking process.

In the era of AI, the importance of chemistry laboratory instruction should not be diminished but rather strengthened. Laboratory instruction serves a function that theoretical instruction cannot replace: students gain sensory experiences — such as changes in color, temperature, gas production, and precipitate formation — through hands-on activities, which no virtual simulation can fully replicate. The uncertainties inherent in the experimental process — such as anomalous results caused by operational errors or new questions raised by unexpected phenomena — can actually serve as opportunities to cultivate students’ abilities to observe carefully, analyze deeply, and adapt flexibly. Hands-on experiments also allow students to experience the entire process of scientific inquiry firsthand, thereby helping them understand the practical origins of scientific knowledge — something that virtual scenarios struggle to replicate. Of course, AI can play a supporting role in laboratory instruction: virtual simulations can help students preview procedural steps and understand experimental principles; utilize intelligent analysis to assist in interpreting experimental data and diagnosing operational issues; and employ safety alerts to prevent hazardous procedures. However, AI cannot replace real-world experimental procedures. Furthermore, chemistry experiments often require group collaboration, a process that helps cultivate students’ sense of cooperation, responsibility, and adherence to standards — educational values that AI cannot provide. Therefore, the correct approach to AI-enabled laboratory instruction is to use AI to augment the effectiveness of experimental teaching, rather than replacing the real experience with a virtual one.

1.3 Essential Skills for the AI Era:

Learning to Learn

“Learning to learn” is the most essential skill in the AI era, yet it has not been given sufficient attention in basic education. In an era of information scarcity, the core mission of education was to help students “acquire knowledge”; in the AI era, with knowledge acquisition more convenient than ever, the core mission of education must shift to helping students “learn how to learn”. Based on the author’s experience using ChatGPT-4, “learning to learn” encompasses at least four dimensions: First, clarifying one’s own needs and accurately defining the boundaries of knowledge; Second, distilling those needs into precise questions; the more precise the questions and the deeper the iteration, the more valuable the AI’s responses will be; third, maintaining a critical perspective on AI outputs, as users must independently assess their scientific validity and credibility — and in chemistry, as an empirical science, experimental verification remains an irreplaceable means of validation; fourth, effectively using AI to structure fragmented knowledge and integrate it into a systematic cognitive framework.

My experience in graduate education has also confirmed this. Since 2013, I have required all incoming master’s and doctoral students to take a MOOC course on sensors or molecular materials offered by a prestigious international university and pass the exam. For more than a decade, students in every cohort have found the course “particularly challenging”, but they have all persevered in the end. They have gained not only an enhancement of their professional knowledge and English proficiency but also a broadening of their horizons and a boost in self-confidence. This has led me to deeply realize that guiding students to a state where they can independently acquire knowledge is far more important than simply imparting specific knowledge to them. This principle applies equally to basic education. However, the reality

is that students at the basic education level generally lack training and habits in self-directed learning, yet “learning how to learn” is precisely the core competency most urgently needed in the AI era — one that must be cultivated from an early age. The growth journey of mathematician Wang Hong, one of this year’s Fields Medal recipients, also corroborates this point. According to reports, she developed the habit of independent learning from an early age; this ability has permeated her academic career and served as a crucial foundation for her outstanding achievements^[5].

2 Three Deep-Seated Issues We Must Confront

2.1 Redefining the Role of Teachers

The role of teachers must be redefined, but “transformation” does not mean “withdrawal”. When the transmission of knowledge can largely be entrusted to AI, the unique value of teachers lies in providing moral guidance, emotional support, and intellectual stimulation. Specifically in chemistry education, after AI has covered foundational topics such as elements, atoms, molecules, atomic structure, chemical bonds, and reaction rates, an excellent chemistry teacher should guide students to think deeply beyond basic concepts: How was Mendeleev able to predict unknown elements? What is the mindset behind scientific discovery? From semiconductor materials, new energy batteries, biopharmaceuticals, and specialty functional materials, to green synthesis and catalytic conversion under the “dual carbon” goals — how does chemistry underpin these critical fields that concern national strategy, the sustainable development of human civilization, and the well-being of the people? What is the relationship between scientific research and social responsibility? Such teaching transcends the mere transmission of knowledge and enters the realm of critical thinking and value guidance.

Recently, scholars Li Xijuan, Zhu Yujun, and Wang Lei co-authored a paper

^[6] pointing out that new technologies, represented by AI, are profoundly transforming scientific research paradigms, social operating models, and forms of knowledge production, thereby necessitating a systematic restructuring of educational goals, teaching models, and disciplinary development. In this transformation, basic education is on the front lines, as this stage is precisely the critical period during which students’ worldviews, outlooks on life, and values are formed. Chemistry education embodies unique educational value: it not only imparts knowledge about material transformations but also, through the discipline’s distinctive modes of thinking, cultivates students’ scientific spirit, rational attitudes, and commitment to truth-seeking. These qualities are precisely what AI cannot easily replace, and they represent the core ground that teachers must defend in the AI era. However, it must also be recognized that if teachers do not proactively transform their practices — stepping away from the rote delivery of knowledge to focus on educational activities of higher value — then the replacement of teachers by AI will no longer be merely a hypothetical scenario at the technical level, but simply a matter of time.

2.2 Systematic Restructuring of the Evaluation System

The failure of the evaluation system is the most profound challenge posed by AI. If students can easily complete homework and tests with the help of AI, can exam scores still reflect genuine learning outcomes? If acquiring knowledge becomes so convenient, how meaningful are assessments that focus on memorization and reproduction? The question is not “whether to ban students from using AI”, but rather “what is truly worth evaluating”: Is it how many chemical reaction equations they have memorized, or their ability to design experimental protocols to solve real-world problems? Is it the ability to recite definitions of concepts, or the ability to apply chemical principles to analyze social issues? This requires shifting

the focus of assessment from “testing knowledge retention” to “assessing competencies and literacy”, from “summative assessment” to “formative assessment”, and from “single-dimensional” to “multidimensional indicators”. Some teachers have already experimented with a “human-machine collaboration” assessment model: students are allowed to use AI tools when completing open-ended tasks, but they must clearly indicate the AI’s contributions and their own independent thinking. The assessment emphasizes problem analysis, solution design, and critical reflection.

Teacher evaluation also faces challenges. If knowledge transmission is primarily handled by AI, and teachers are then evaluated based on students’ test scores, this is not only unfair but also lacks a theoretical foundation. We need to explore a new teacher evaluation system that incorporates curriculum design skills, learning facilitation skills, and student development guidance skills into the evaluation framework. School administration also requires a systematic overhaul: Is a standardized curriculum schedule still necessary? Is the traditional classroom-based instruction model still the only organizational form? As personalized learning becomes the norm, a series of supporting systems — including credit recognition, examination systems, and the calculation of teacher workloads — will need to be redesigned. Textbook development is also undergoing a transformation: Printed textbooks are no longer the primary vehicle for knowledge; future chemistry textbooks may increasingly serve as learning roadmaps and problem sets.

2.3 Upholding the Bottom Line in AI-Empowered Education

In the process of advancing AI-enabled education, there are several bottom lines that must be upheld. First, we must guard against the risk of mental inertia. If students become accustomed to obtaining ready-made answers from AI, their ability to think independently may deteriorate. The appeal of chemistry

lies in exploring the unknown; if students merely passively accept conclusions and no longer ask “why” or “are there other possibilities,” the very essence of chemistry education will be lost. Second, we must be vigilant against the widening of the digital divide. Access to AI educational resources depends on hardware and internet connectivity; if high-quality resources are concentrated in developed areas and top-tier schools, the educational gap between urban and rural areas — as well as across regions — may widen further. Third, we must not stray from the essence of education. Efficiency is not the most important goal of education. Instilling values, shaping character, and fostering emotional growth require us to slow down and engage in deep, person-to-person interaction. Students in basic education are in a critical phase of character development; they need not only highly efficient knowledge input but, more importantly, a nurturing environment for growth. Fourth, we must guard against oversimplifying the role of teachers. A teacher’s core value lies precisely in what AI cannot do: observing students’ emotional changes, seizing unexpected moments in the classroom, discovering students’ unique qualities, and helping them build self-confidence. These educational practices — which are difficult to quantify — are the true embodiment of a teacher’s professionalism.

3. Teacher Training and Professional Development Empowered by AI

Discussions on AI-enabled basic chemistry education have largely focused on the instructional level, but two more fundamental issues have been widely overlooked: the lag in the training of pre-service teachers and the challenges faced by in-service teachers in continuing their professional development. In a sense, these two issues deserve more attention than the AI tools themselves, as they will determine the quality of chemistry education at the basic education level for quite some time to come.

3.1 The Lag in Teacher Education and Its Restructuring

The lag in teacher education curricula represents a latent crisis. Currently, chemistry programs at teacher training institutions generally still follow the basic framework of “subject knowledge instruction + study of educational theory + teaching skills training + teaching practicum.” This framework was reasonable in the past, as teacher candidates needed to acquire sufficient knowledge of chemistry before stepping into the classroom. However, in an era where AI can efficiently impart knowledge, should the focus of teacher education be adjusted?

The problem lies not only in the content and teaching methods of specialized courses, but also in the severe lag in pedagogy courses. Current educational theory studies and teaching skills training still assume a traditional classroom setting, and core courses — such as instructional design, classroom organization, and student assessment — hardly take AI into account. Prospective teachers learn how to design instructional processes, how to ask questions, and how to organize discussions, but they are rarely guided to consider: When AI can instantly answer students’ questions, how should teachers adjust their questioning strategies? When every student has a personalized AI learning companion, how will the foundation and methods of classroom discussions change? When AI can automatically grade assignments, how should the function and form of assessment be redefined? These are not issues of subject-specific knowledge, but rather issues that require a fundamental restructuring of pedagogy itself.

The foundation of subject knowledge also needs to be reevaluated. Pre-service teachers still need to possess a solid foundation in chemistry, but the meaning of “solid” is changing. In the past, “solid” meant memorizing a large number of facts, formulas, and reactions and being able to recall them at any time; in the future, “solid” will increasingly mean a deep understanding

of the discipline’s core concepts and methodological approaches, the ability to assess the accuracy of AI-generated content, and the ability to translate abstract principles into problem scenarios that students can relate to. The specific details of knowledge that AI can provide at any time do not necessarily need to occupy the teacher candidates’ valuable memory capacity; conversely, the subject-specific insight and judgment that AI cannot replace must be reinforced even more.

Reforming the content of pedagogy courses is more urgent than adjusting specialized coursework. Chemistry pedagogy courses require a systematic update: How can student learning be assessed in an AI-assisted environment? How can AI be used to support differentiated instruction and personalized guidance? How can inquiry-based learning tasks involving human-AI collaboration be designed? How can students be guided to critically evaluate answers provided by AI? These topics should form the core modules of teaching competency training for the next generation of pre-service teachers. If pedagogy courses themselves do not undergo innovation, pre-service teachers will enter new classrooms equipped with an outdated toolkit—and this is precisely the crisis that warrants the greatest vigilance in the coming years.

Adjustments to teacher education cannot be limited to adding one or two elective courses on “AI tool usage”; instead, a more systematic approach is needed. First, prospective teachers should be given the opportunity to deeply experience the process of AI-assisted learning as learners themselves — just as the author did when using ChatGPT-4 to study millimeter-wave communication and terahertz detection. Only by personally experiencing the iterative process of “asking-answering-probing” and understanding the strengths and limitations of AI can they effectively guide students in their future teaching. Second, it is necessary to cultivate pre-service teachers’ instructional design

skills in AI-assisted environments: when to have students ask questions directly to AI, when to organize face-to-face discussions, and when the teacher needs to provide explanations in person — these judgments require experience gained through practice. Third, pre-service teachers must be trained in classroom management skills within AI-assisted environments: When each student is at a different stage of AI-guided learning, how can teachers coordinate the instructional pace for the entire class? How can they ensure that classroom discussions remain effective? How can they monitor the learning progress of every student? These issues are rarely addressed in traditional pedagogy courses.

More fundamentally, teacher education needs to rethink the core competencies of chemistry teachers. In the future, an excellent chemistry teacher may no longer need to memorize all chemical equations (since AI can provide them at any time), but must be able to design learning scenarios that inspire students' curiosity; must be able to identify the confusion students encounter during AI-assisted learning and provide effective guidance; and must be able to help students develop critical thinking and scientific judgment after they have been exposed to a large amount of AI-generated information. Cultivating these competencies requires systematic adjustments to the teacher education curriculum, rather than piecemeal fixes. The inertia of teacher education is formidable, and adjusting training programs takes time — but the rapid spread of AI will not wait.

3.2 Challenges and Solutions for the Continuing Education of In-Service Teachers

The challenges facing in-service teachers' continuing education represent an immediate crisis. Most of the hundreds of thousands of chemistry teachers currently working in K-12 education were trained under a traditional educational model centered on the teacher and focused on the

transmission of knowledge. Although many of them have heard of AI, they lack systematic training and practical experience. A common phenomenon is this: schools introduce AI teaching platforms, and teachers attend training to master basic operations; yet, once back in the classroom, they continue to use their original teaching methods, treating AI merely as an “auxiliary tool” used only occasionally — its potential remains far from being fully tapped. This situation does not stem from a lack of effort on the part of teachers; rather, the transformation brought about by AI-empowered education involves every aspect of teaching, and training in operational skills alone is far from sufficient. Teachers need to redefine their roles, redesign curriculum structures, and rethink assessment methods — all of which cannot be addressed through superficial training alone. Even more concerning is that, when promoting AI-based instruction, some schools simply require teachers to “just use it”, without establishing systematic institutional follow-up, providing ongoing academic support, or forming the necessary learning communities.

Currently, most AI training programs for teachers are limited to “feature introductions and operational demonstrations”, which are disconnected from real-world teaching scenarios. Teachers need more than a general understanding; they require specific guidance tailored to the unique characteristics of chemistry as a subject. For example, how can AI be used to explain atomic structure? How can AI be used to design tiered assignments? How can AI support laboratory instruction? How can teachers identify incorrect information provided by AI? These are the practical skills teachers truly need to master.

Establishing teacher learning communities is a viable approach. When teachers within the same school or district form learning communities and regularly share their attempts, challenges, and experiences with AI-assisted

teaching, individual explorations coalesce into collective wisdom. One teacher may discover that using AI to organize discussions on the theme of “Chemistry and Daily Life” yields excellent results, while another may develop a method for designing tiered assignments using AI. Through communication within the community, these scattered experiences are consolidated, validated, and disseminated — a process far more dynamic than top-down, standardized training.

4. Recommendations and Outlook

Recommendation 1: Restructure teacher education programs to incorporate AI literacy into core curricula. Chemistry teacher education programs should maintain a solid disciplinary foundation while adding modules such as AI-assisted instructional design and human-machine collaborative classroom organization. This will enable student teachers to deeply experience AI-assisted learning as learners themselves, helping them understand the advantages, limitations, and impact of AI on learning methods before they step into the classroom. It is recommended that the Ministry of Education add requirements related to AI literacy to its accreditation standards for teacher education programs to drive curriculum adjustments at teacher training institutions nationwide. A specialized research project on “Core Competencies for Chemistry Teachers in the AI Era” should be launched to provide theoretical support for adjustments to training programs. At the same time, teacher training institutions should take the lead in developing model courses and case repositories for AI-assisted instruction, providing teacher candidates with practical resources they can observe and emulate.

Recommendation 2: Establish a support system for the continuous professional development of in-service teachers. Education administrative departments should incorporate AI literacy into the mandatory curriculum for teacher training, placing particular

emphasis on targeted training for subjects such as chemistry, rather than providing general technical introductions. Schools and educational research departments should promote a transformation in teaching and research methods, shifting from the traditional “class observation and evaluation” approach to a “research-practice-reflection” model, and establish teacher learning communities to pool individual explorations into collective wisdom. Educational research activities and teaching competitions at all levels should promptly incorporate AI-assisted teaching capabilities into their evaluation criteria to serve as a guiding force. In particular, two extremes must be avoided: first, “using without researching” — where platforms are installed and equipment is provided but ongoing professional support is lacking; and second, “being afraid to use it or not knowing how to use it” — where educators feel at a loss in the face of the technological wave. It is recommended that special funding be allocated to support teachers in conducting action research on AI-assisted teaching, enabling them to grow through practical experience.

Recommendation 3: Systematically

advance reforms to the evaluation system. Shift student assessment from testing knowledge retention to evaluating competencies and literacy, and incorporate formative and performance-based assessments into the formal framework. Explore a “human-machine collaboration” assessment model that allows students to use AI in open-ended tasks — provided they attribute the AI’s contributions — with the focus of evaluation placed on problem analysis, solution design, and critical reflection. Reform teacher evaluation by incorporating course design capabilities, learning facilitation skills, and student development guidance abilities into the system. At the school administrative level, curriculum and teaching arrangements should be restructured to reduce the weight of standardized tests and increase the weight of open-ended tasks and practical assessments. It is recommended that education authorities organize experts to develop evaluation guidelines for core competencies in chemistry in the AI era, providing a practical reference framework for frontline teachers and schools.

The foundational, pervasive, and supportive nature of chemistry means

that the quality of chemistry education is directly linked to the cultivation of a nation’s scientific and technological competitiveness and to the sustainable development of human civilization^[7]. Seizing the historic opportunity presented by AI-empowered education is of great significance for cultivating a new generation of young people who possess a sense of national pride, a sense of responsibility, and innovative capabilities. However, technology is ultimately just a tool; the essence of education lies in nurturing people. While AI can help students acquire knowledge more quickly, it cannot replace teachers in sowing the seeds of the scientific spirit in students’ hearts, igniting the spark of curiosity, or guiding their pursuit of values. Let us safeguard the true nature of education amid technological empowerment and anchor our educational direction amid transformation and innovation, so that we may cultivate a next generation capable of mastering AI tools while possessing independent character and a scientific spirit.

Without chemistry, there is no future; basic chemistry education has a bright future in the age of AI.

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我的大学 我的恩师（二）

何刚

四、入室

二〇〇五年八月，因本科即在师大就读，我不过是简单地从一栋楼搬至另一栋楼，便提前加入了实验室。从那时起我才逐渐与房老师有了更深接触。由于心中始终对他充满敬畏，不敢大声言语，听不懂房老师口中的各类学术术语，不明白他与师姐们讨论的科学问题，更无从知晓如何设计一个实验。

记得有一天，房老师将我叫到他的办公室。房老师办公室的格局，在我印象中多年来从未改变，里外是一个套间，里间是办公室，外间是一个小会议室。外间那张会议桌，从我初次踏入房老师办公室便已在那里，如今仍安放在陕师大新概念传感器与分子材料研究院房老师的办公室中。每次坐于此处，心中都不禁感慨万千。

在那隔开的小会议室里，房老师交给我人生中第一个研究课题，也是此后我几乎无法绕开的一个关键词。他要我做共轭高分子（conjugated polymers）。一听到“polymer”已颇感头疼，再加上一个全然不解的“conjugated”，心中实在紧张不已。房老师耐心地为讲解，大约有一个小时之久，讲述了共轭高分子为何物，也教会我如何查阅相关文献、如何研读一篇论文。这大抵是我人生中真正意义上的科研第一课。

十分幸运的是，彼时房老师坚持亲自为我们讲授荧光原理课程，也让我拥有了人生中第一本英文教材，Lakowicz 教授的《Principles of Fluorescence Spectroscopy》。因是房老师学生的缘故，实验室的高师姐给我们每人发放了一本英文教材。我们

满心欢喜地接过这本书，翻开后方才发觉阅读起来是何等艰难。但正因是房老师亲自讲授的课程，我们必须啃下这块硬骨头。那时我们研究生班人数不多，通常仅十人左右，可因房老师授课的缘故，那门课竟有二三十人之多。因我是房老师的学生，相关材料的整理、上课时间的安排等，均由我负责。

房老师的课极有意思。他虽发了《荧光原理》这本教材，但上课所用皆是亲自撰写的讲义，从来都是从板书开始。这对我冲击极大，满黑板的英文基本原理，让我们听得如痴如醉，那可能是我记得最认真的一本笔记了。次年，我将这本笔记交给了后来修读此课的晏妮同学。彼时房老师已是陕师大校长，但据我所知，这门课他从未缺席过任何一堂。为学好这门课，



我摸索出一个小小的诀窍，在此不妨分享一二，这也是我常对自己的学生讲起的。进入实验室后，为了弄懂这些知识，直接啃读英文原著显然力有不逮，自己英语基础薄弱，也缺乏啃完那本大部头的恒心。于是我便找来高莉宁师姐、丁立平师姐的硕士论文，将房老师的讲义、师姐们的毕业论文放置于宿舍床头，每晚回到寝室便细细研读。我自幼读书便信奉一句话：“书读百遍，其义自见”。也正是从那时起，我才真正明白了课题组在做什么研究、为何要做这些研究、以及如何去做这些研究。

在此之前，高莉宁、丁立平、吕凤婷、张淑娟、亢建平、胡静几位师姐均集中精力研究多环芳烃，萘（pyrene）是实验室最常用的荧光基团。而我接手的共轭高分子，不仅对我而言是全新的，对整个实验室来说也是从未涉足的方向。房老师以极其敏锐的学术洞察力，为我选定了这一课题，从共轭高分子的原理与发展历程，到与爆炸物检测相结合，再到如何制备薄膜，有太多问题需要我们去探索、去学习、去认识。

那时，房老师因行政工作繁重，周一至周五白天几乎无法长时间来实验室，唯有中午偶尔会来，每日傍晚下班后则会从师大人称为“白宫”的行政楼来到实验室。多年以后我才得知，房老师当时推掉了无数邀请，只愿将仅有的时间留给实验室。大学时期，自己十分贪玩好动，每日下午多半不是在运动，便是与朋友们嬉闹。进入实验室后，见房老师如此勤勉敬业，或者说是为了让自己变得更好一些，我便告诫自己，务必改掉那些不良习惯。从那时起，我坚持中午不回寝室，困了便在桌上伏案小憩；每日傍晚六时或更早去吃晚饭，餐后尽快返回实验室工作。未曾想这一习惯，多年后被房老师反复提及。我想，这不过是受房老师感召而做出的一点小小改变。或许也正是这些细微的改变，

使我在科研道路上得以坚持走下去。

那段时间，房老师极其忙碌。彼时有师姐赴国外从事博士后研究，实验室的一些杂务与公共事务，我便承担了许多。如今想来虽微不足道，但在当时，我想自己已真正将实验室当作自己的家了。这一点说来简单，但我以为，这是我对现在学生最基本的要求。

科研之路并非坦途。在共轭高分子方向上，房老师为我设计了聚硅烷、聚噻咯、聚苯乙烯撑等几个研究课题。彼时我全然不知如何进行无水无氧实验，或者说严格意义上的无水无氧操作。房老师便请来刚从德国归来的张国防老师，手把手地指导我。至今我仍十分感念张老师的帮助，是他帮我搭建起第一套无水无氧装置，教我如何干燥溶剂。如今学生们已普遍使用超干溶剂，科研条件确已今非昔比。

然而我仍在科研上走了不少弯路，始终未能取得理想的成果。为了赢得充足的时间，我于二〇〇七年参加了硕博连读答辩，直接由硕转博。在那次答辩中，也结识了后来成为我在西安交通大学的同事兼好友的妥建清同学，他的导师是尤西林先生。同年，同级的李慧慧同学在房老师指导下顺利完成硕士学业后，获得了赴日本攻读博士学位的机会。有人常说“对比才是痛苦的根源”，此言虽有待商榷，但彼时的心境确是如此。目睹同学出国深造，在那个年代，很难说我的内心是平静的，应该说有着不少的波澜。

五、地震那一课

二〇〇八年注定是一个不平凡的年份。那一年发生了诸多大事，北京奥运会的举世欢腾，席卷全球的金融危机，但我印象最深的，仍是汶川大地震。

因我们地处西安，受汶川地震波及的影响十分强烈。那时我已是博士二年级，算是课题组中高年级的学生。二〇〇八年五月十二日下午，房老师

仍为研究生讲授荧光原理课程。课程安排在陕师大七号楼六层的会议室，下午二时三十分开始。六层会议室是当时学院条件最好的会议室，许多学术会议均在此举行。即便如此，向来严谨治学的房老师查看了会议室的投影仪后，仍让我取来课题组的投影仪，因为效果更佳，那时房老师已开始采用PPT配合板书的方式授课。房老师交代的事，我向来置于首位。下午两点我便抱着投影仪来到会议室，迅速而熟练地架设调试完毕，便在教室等候房老师。看着学生们陆续入座，我不禁想起自己当年听课的情景。后来才得知，我的师弟彭浩南，正是当时听课的学生之一。我喜欢坐在教室后排听房老师讲课，但那时房老师总会“无情”地将我赶出去，让我回实验室做工作。

房老师有一个习惯，每次上课都会提前至少十五分钟抵达教室。那日两点二十分左右，房老师来到教室，开始与学生交流。查看完设备无误后，我就下楼返回六号楼的实验室。途中，忽然感到一阵天旋地转。事实上我一时尚未意识到发生了什么，直到有人高喊了一声“地震了！”彼时脑中只有一个念头，立刻冲上楼梯奔回教室。到了教室门口，见房老师正站在窗边向下张望，想要看看外面的情况。我大喊一声“地震了！”房老师当即喊道：“让学生们先走！不要坐电梯！”这句话令我终身难忘。我知道房老师习惯电脑不离身，便顺手拿起房老师置于桌上的笔记本电脑。房老师组织学生有序撤离教室，他自己才最后一个离开。我们的七号楼据说是苏联援建的，已有数十年历史，楼梯还是悬空式结构。房老师与我并肩走在最后，整个楼梯上只有学生们窸窣的脚步声，无人言语。楼梯上如乘坐摇晃不已的船上一般，我搀扶着房老师，心中不知会有怎样的结果。短短一两分钟，心中激起万千思绪，但与房老师在一起，心中便有莫大的勇

气。所幸，我们的楼梯经受住了考验。后来才知，那次地震确实造成了极大的灾难，不仅在汶川，西安亦同受波及。

下楼之后，房老师立刻奔赴行政主楼。我则茫然地立于楼下。此后之事，众人皆心有余悸。在学校的统一指挥下，整个校园开始了有条不紊的恢复工作。房老师也第一时间安排对实验室进行全面安全检查。那也是我那几日接到的房老师唯一的指示。心中常想，为何彼时会做出那样的决定？或许便是房老师平日里的言传身教，以及我对房老师发自内心的敬仰使然吧。

六、师之严

此前总以为房老师既是校长，又是大科学家，应该没有什么烦心之事。后来在共餐时听房老师谈起，才知背后有诸多艰辛。房老师有一个习惯，周六周日只要不出差，便会在实验室待着。中午则喜欢让我们去附近带几个简单的小菜，他自己掏钱为我们改

善伙食。这也是我们那时极为享受的一件事，与房老师共进午餐，还是房老师请客改善生活。用餐时，听房老师谈论科学，偶尔也会说起学校发展中的一些往事，才知道房老师在学校的发展历程中经历了诸多不易。那些往事在房老师近年来撰写的几篇文章中，我读来别有一番感触，或许也是因为在那些共餐的时光里，曾亲耳听他讲述过的缘故吧。

我们有时工作并不够努力。记忆中我曾见过房老师两次大发雷霆。一次是吕凤婷师姐，如今在中国科学院化学研究所任研究员，彼时带我们一同去团建，其实就是外出聚餐，整个实验室的人都出去玩了。房老师来到实验室，发现空无一人，十分生气，给我们打电话，我们都不敢接听。如今回想起来真是愚钝，那一次恐怕当真触怒了房老师。次日中午，房老师从行政楼下班后，召集我们到会议室开会。从未见过房老师发那般大的脾

气，我硬咬着牙接受批评，眼见吕师姐已泪流满面。那时我们尚不甚理解，如今自己做了老师，方能体会房老师当时怒其不争、恨铁不成钢的心情。

虽然后来我们都十分努力，但科研工作并非一帆风顺。我从二〇〇五年进入课题组，直至二〇〇八年，学术论文仍未发表。记得某个周末的中午，房老师为我修改论文，询问上周交代的实验我是否完成。我以种种理由推脱。当房老师问到第三、第四个实验，问我是否补做了，我都回答“没有”时，在某一瞬间，我分明感到房老师想要举起手，如同要教训自己的孩子一般。我当时十分害怕。人生便是这般荒诞。那时我用的是一部直板手机。或许是上午房老师与我通完电话，中午我不敢去吃饭。房老师工作至一点半左右欲稍作休息，我这才将手机揣进口袋准备去吃饭。谁知鬼使神差地触动了回拨键，给房老师拨去了电话。手机在口袋里，我浑然不觉。





房老师听我未出声，挂断后回拨过来，我又将手机调至静音，未曾接听。房老师或许担心我内心脆弱，生出什么意外。孰料那时我正闷头吃着一大碗面，如今想来既滑稽又愧疚。等吃饱喝足拿起手机，看到房老师数个未接来电，急忙跑到房老师那里，自然免不了一顿严厉的训斥。那时或许不仅是我的不懂事，更是老师对学生安危的深深牵挂。自那以后，我基本再未惹房老师生气，这或许便是自己成长的标志吧。

后来我成了实验室的大师兄。杜海英、王红月、彭浩南、张荷兰、崔红等几位师弟师妹相继加入，课题组由此步入更快的发展轨道，此后便日益顺利。多位师弟师妹在房老师的鼎力支持下，均直接赴国外攻读博士学位。我仍留在实验室跟随房老师从事基础研究，也在爆炸物探测仪的工作上投入了大量精力。二零零八年实验室从七号楼迁至六号楼，二零一一年

从六号楼迁至长安校区的致知楼，我皆是主力，完成了实验室的历次搬迁。

至二〇一一年前，许多师弟或同门均在国外求学，晏妮也于二〇一〇年赴美国乔治城大学进行联合培养。博士毕业之际，或许因自己表现尚可，我非常希望能留校工作。彼时与我们合作多年的辛云宏老师向我提供了一个如今看来仍属不错的机会，留校任职。当我兴冲冲地将此消息告知房老师，表示想留在实验室或担任讲师时，不料房老师断然拒绝，更将为我提供机会的辛老师也一并批评了，至今仍让我心中十分过意不去。房老师给我指了一条路：人生须有更高的追求，必须去从事博士后研究。这也彻底断绝了我留校担任讲师的念想。眼见同级同学成绩尚不如我，且我身为校长的学生，竟无留校机会，心中不免有些失衡。时至今日，才明白房老师的一片苦心。

联系博士后的过程颇为艰难。最

终拿到数份 offer 后向房老师汇报，房老师也让我学到了一个单词，因房老师要求我们每次给他写信须用英文。记得当我向他汇报几个 offer 时，他的第一句话是：“Don't be silly. Go to Canada.”我方首次知晓“silly”一词。于是毅然决定，前往加拿大从事博士后研究。

时光飞逝。二〇一一年六月，我迎来了博士论文答辩。房老师特意邀请江雷院士担任我的答辩委员会主席，我心中既惊喜又忐忑。邀请大家来主持答辩，自然是对我博士工作的认可，但同时也带来了极大压力。众所周知，江雷老师是一位极为严格的科学家。答辩当日，他提出了若干颇具深度的科学问题，着实令人难以招架。所幸对于自己的博士论文还算熟悉，终归有惊无险地完成了答辩。

（连载二，未完待续）

My University, My Mentor (II)

He Gang

IV. Joining Fang Group

In August 2005, since I had been attending Shaanxi Normal University since my undergraduate years, I simply moved from one building to another and joined the lab ahead of schedule. It was only then that I gradually began to interact more closely with Prof. Fang. Because I had always held him in such high regard, I didn't dare speak up. I couldn't understand the various academic terms he used, nor did I grasp the scientific issues he discussed with the senior female students, and I had no idea how to design an experiment.

I remember one day when Prof. Fang called me into his office. As far as I can recall, the layout of Prof. Fang's office has remained unchanged over the years: it consists of an inner and outer room, with the inner room serving as his office and the outer room as a small conference room. The conference table in the outer room has been there ever since I first set foot in Prof. Fang's office, and it still stands today in his office at the Institute of New Concept Sensors and Molecular Materials at Shaanxi Normal University. Every time I sit there, I can't help but feel a flood of emotions.

In that small conference room, Prof. Fang assigned me my first research project — one that would become a key concept I could hardly avoid for the rest of my life. He asked me to work on conjugated polymers. Just hearing the word “polymer” was enough to give me a headache, and with the addition of the completely unfamiliar term “conjugated”, I was truly nervous. Prof. Fang patiently explained everything to me for about an hour, describing what conjugated polymers were and teaching me how to search for relevant literature and how to analyze a research paper. This was, in all

likelihood, my very first real lesson in scientific research.

Fortunately, Prof. Fang insisted on teaching the course on the principles of fluorescence himself at that time, which also gave me my very first English-language textbook: Prof. Lakowicz's *Principles of Fluorescence Spectroscopy*. Because we were Prof. Fang's students, senior labmate Miss Gao Lining distributed a copy of the English textbook to each of us. We accepted the book with great joy, only to realize upon opening it just how difficult it was to read. But precisely because Prof. Fang was teaching the course himself, we had to tackle this tough challenge head-on. At that time, our graduate class was small, usually only about ten students, but because Prof. Fang was teaching the course, the class swelled to as many as twenty or thirty students. Since I was Prof. Fang's student, I was responsible for organizing the relevant materials and scheduling class times.

Prof. Fang's classes were incredibly engaging. Although he distributed the textbook *Principles of Fluorescence Spectroscopy*, he used lecture notes he had written himself for every class and always began by writing on the blackboard. This had a profound impact on me; the blackboard filled with fundamental principles in English captivated us completely, and those are probably the most meticulous notes I've ever taken. The following year, I passed these notes on to my classmate Yan Ni, who was taking the course later on. By then, Prof. Fang had already become the president of Shaanxi Normal University, but as far as I know, he never missed a single class for this course. To master this subject, I figured out a little trick, which I'd like to share here — it's

something I often tell my own students as well. Once I entered the group, I realized that trying to grasp this material by plowing through the original English texts was clearly beyond my capabilities at the time — my English foundation was weak, and I lacked the perseverance to work my way through such a massive tome. So I obtained the master's theses written by my senior classmates Gao Lining and Ding Liping. I placed Prof. Fang's lecture notes and my seniors' theses on my bedside table in the dorm, and every night when I returned to my room, I would pore over them carefully. Ever since I was a child, I've lived by the saying: “Read a book a hundred times, and its meaning will become clear”. It was precisely from that point on that I truly understood what research the lab was conducting, why we were doing it, and how to go about it.

Prior to this, my senior labmates — Gao Lining, Ding Liping, Lü Fengting, Zhang Shujuan, Kang Jianping, and Hu Jing — had all focused their research on polycyclic aromatic hydrocarbons, with pyrene being the most commonly used fluorescent group in the lab. The conjugated polymers I took on, however, were not only entirely new to me but also a field the entire lab had never explored before. With his exceptionally keen academic insight, Prof. Fang selected this research topic for me. From the principles and historical development of conjugated polymers to their application in explosive detection, and on to the preparation of thin films, there were countless questions for us to explore, learn, and understand.

At that time, due to his heavy administrative workload, Prof. Fang was almost never able to spend long periods in the lab during the day from Monday

through Friday. He would only drop by occasionally at lunchtime, and every evening after work, he would come to the lab from the administration building — known among the university community as the “White House”. It wasn’t until many years later that I learned Prof. Fang had turned down countless invitations at the time, choosing instead to devote his limited free time entirely to the lab. During my college years, I was quite playful and restless; most afternoons were spent either playing sports or fooling around with friends. After joining the lab and witnessing Prof. Fang’s diligence and dedication — or perhaps simply to better myself — I resolved to break those bad habits. From then on, I made it a point not to return to my dorm at lunchtime; if I felt sleepy, I would simply rest my head on my desk for a quick nap. Every evening at six o’clock — or even earlier — I would go to dinner, and after eating, I would return to the lab as quickly as possible to continue my work. I never imagined that, many years later, Prof. Fang would repeatedly mention this habit of mine. I suppose it was just a small change I made, inspired by Prof. Fang’s example. Perhaps it was precisely these subtle changes that enabled me to persevere on my path in scientific research.

During that period, Prof. Fang was extremely busy. At the time, one of my senior labmates had gone abroad to pursue postdoctoral research, so I took on many of the lab’s administrative and general duties. Looking back now, these tasks may seem insignificant, but at the time, I felt I had truly come to regard the lab as my home. It’s easy to say, but I believe this is the most basic requirement I have for my current students.

The path of scientific research is not an easy one. In the field of conjugated polymers, Prof. Fang designated several research projects for me, including polysilane, polythiophene, and polystyrene-based polymers. At that time, I had absolutely no idea how to conduct anhydrous and anoxic experiments — or, more precisely,

how to perform anhydrous and anoxic procedures in the strictest sense. Prof. Fang therefore invited Prof. Zhang Guofang, who had just returned from Germany, to provide me with hands-on guidance. To this day, I remain deeply grateful for Prof. Zhang’s help; it was he who helped me set up my first anhydrous and oxygen-free apparatus and taught me how to dry solvents. Today, students commonly use ultra-dry solvents, and research conditions are indeed a far cry from what they used to be.

However, I still took quite a few detours in my research and did not achieve the results I had hoped for. To give myself ample time, I participated in the integrated master’s-to-PhD defense in 2007, transitioning directly from my master’s program to a PhD program. During that defense, I met Tu Jianqing, who later became both a colleague and a close friend of mine at Xi’an Jiaotong University; his advisor was Prof. You Xilin. That same year, my classmate Li Huihui, under the guidance of Prof. Fang, successfully completed her master’s program and was offered the opportunity to pursue a PhD in Japan. People often say, “Comparison is the root of suffering”. While this statement is open to debate, that was certainly how I felt at the time. Witnessing a classmate go abroad for further studies — especially in those days — it would be hard to say that I was at peace; in fact, my heart was quite unsettled.

V. The Lesson Learned at the Earthquake

The year 2008 was destined to be an extraordinary one. Many major events took place that year — the worldwide celebration of the Beijing Olympics and the global financial crisis — but what left the deepest impression on me was still the Wenchuan Earthquake.

Since we were located in Xi’an, we were severely affected by the Wenchuan earthquake. At that time, I was in my second year of my PhD program and was considered one of the senior students in the research group.

On the afternoon of May 12, 2008, Prof. Fang was still teaching a course on the principles of fluorescence to graduate students. The class was scheduled to take place in the conference room on the sixth floor of Building 7 at Shaanxi Normal University, beginning at 2:30 p.m. The sixth-floor conference room was the best-equipped meeting room in the university at the time, and many academic conferences were held there. Even so, Prof. Fang — who was always meticulous in his academic work — checked the conference room’s projector and still asked me to bring our research group’s projector, as it provided better quality. By then, Prof. Fang had already begun using PowerPoint presentations in conjunction with blackboard notes for his lectures. I always made Prof. Fang’s instructions my top priority. At 2:00 p.m., I carried the projector to the conference room, set it up and calibrated it quickly and skillfully, and then waited for Prof. Fang in the room. Watching the students take their seats one by one, I couldn’t help but recall my own days as a student attending his lectures. I later learned that my junior, Peng Haonan, was one of the students in the audience that day. I used to enjoy sitting in the back row of the classroom to listen to Prof. Fang’s lectures, but back then, he would always “mercilessly” shoo me out, telling me to return to the lab to work.

Prof. Fang had a habit of arriving at the classroom at least fifteen minutes early for every class. Around 2:20 that day, Prof. Fang entered the classroom and began talking with the students. After confirming that all the equipment was in order, I went downstairs to return to the lab in Building 6. On the way, I suddenly felt the world spinning. In fact, I didn’t immediately realize what was happening until someone shouted, “Earthquake!” At that moment, I had only one thought: I immediately rushed up the stairs and ran back to the conference room. When I reached the conference room, I saw Prof. Fang standing by the window, looking down to assess the situation outside. I shouted, “Earthquake!” Prof. Fang

immediately yelled, “Have the students leave first! Don’t take the elevator!” Those words have stayed with me for the rest of my life. Knowing that Prof. Fang was in the habit of never being without his computer, I instinctively picked up his laptop, which was sitting on the desk. Prof. Fang organized the students to evacuate the room in an orderly manner, and he was the very last to leave. Our Building 7 was reportedly built with aid from the former Soviet Union and was already several decades old; the stairwell still featured an open-riser design. Prof. Fang and I walked side by side at the very back; the only sound on the entire staircase was the rustling of the students’ footsteps — no one spoke. Walking down the staircase felt like being on a violently rocking boat. I supported Prof. Fang, unsure of what the outcome would be. In just a minute or two, a thousand thoughts raced through my mind, but being with Prof. Fang gave me immense courage. Fortunately, the staircase withstood the test. I later learned that the earthquake had indeed caused immense devastation — not only in Wenchuan but also in Xi’an.

After going downstairs, Prof. Fang immediately rushed to the main administration building. I, on the other hand, stood there in a daze. What happened next left everyone feeling deeply shaken. Under the university’s unified command, the entire campus began an orderly recovery effort. Prof. Fang also arranged for a comprehensive safety inspection of the laboratory as soon as possible. That was the only instruction I received from him during those few days. I often wonder why I made that decision at the time. Perhaps it was due to Prof. Fang’s daily guidance through both words and actions, as well as the deep respect I felt for him from the bottom of my heart.

VI. My Strict Mentor

I had always assumed that since Prof. Fang was both the university president and a renowned scientist, he must have had few worries. It wasn’t

until I heard him speak about it during a meal together that I realized there were many hardships behind the scenes. Prof. Fang had a habit of spending Saturdays and Sundays in the lab whenever he wasn’t away on business. At lunchtime, he would ask us to pick up a few simple dishes from a nearby restaurant or canteen, and he would pay out of his own pocket to treat us to a better meal. This was something we truly looked forward to back then — having lunch with Prof. Fang, especially when he treated us to a special meal. During meals, as Prof. Fang discussed science and occasionally shared anecdotes about the school’s development, I came to realize just how many hardships he had endured throughout the institution’s history. Reading about those stories in several articles Prof. Fang has written in recent years evoked a special sense of emotion in me — perhaps because I had heard him recount them firsthand during those shared meals.

Sometimes we don’t work hard enough. I recall seeing Prof. Fang lose his temper twice. One time involved our senior classmate Lü Fengting — now a researcher at the Institute of Chemistry, Chinese Academy of Sciences — who took us on a team-building outing, which was really just a group dinner, with the entire lab going out to have fun. Prof. Fang arrived at the lab to find it completely empty. He was furious and called us, but none of us dared to answer. Looking back now, it was truly foolish of us — that incident must have genuinely angered Prof. Fang. The next day at noon, after finishing work at the administration building, Prof. Fang summoned us to the conference room for a meeting. I had never seen Prof. Fang lose his temper like that before; I gritted my teeth as I endured his criticism, while Lü was already in tears. At the time, we didn’t fully understand, but now that I’ve become a teacher myself, I can truly appreciate Prof. Fang’s frustration at our lack of drive and her disappointment that we weren’t living up to our potential.

Although we all worked very

hard afterward, our research did not go smoothly. I joined the research group in 2005, but by 2008, I still hadn’t published any papers. I remember one weekend at noon, Prof. Fang was editing my paper and asked if I had completed the experiments he had assigned the previous week. I made various excuses to avoid answering. When Prof. Fang asked about the third and fourth experiments and whether I had made up for them, and I replied “no” to both, there was a moment when I distinctly felt that Prof. Fang was about to raise his hand, as if he were about to discipline his own child. I was terrified at that moment. Life is just that absurd. At the time, I was using a bar phone. Perhaps because I’d spoken with Prof. Fang on the phone that morning, I didn’t dare go out for lunch. Prof. Fang worked until around 1:30 p.m. and wanted to take a short break; only then did I slip my phone into my pocket and prepare to go eat. But as if by some strange twist of fate, I accidentally pressed the redial button and called Prof. Fang. My phone was in my pocket, and I didn’t even notice it. When Prof. Fang didn’t hear me answer, he hung up and called back. I switched my phone to silent mode and didn’t pick up. Prof. Fang was probably worried that I was emotionally fragile and that something might have happened to me. Little did he know that at that very moment, I was just busy eating a big bowl of noodles — something that, looking back now, seems both ridiculous and shameful. After I’d finished eating and picked up my phone, I saw several missed calls from Prof. Fang. I hurried over to her office, where, naturally, I couldn’t avoid a stern scolding. At the time, it wasn’t just my immaturity — it was also the teacher’s deep concern for her students’ safety. Since then, I’ve rarely made Prof. Fang angry again; perhaps that’s a sign of my own growth.

Later, I became the senior-most graduate student in the lab. Several junior colleagues — including Du Haiying, Wang Hongyue, Peng Haonan, Zhang Holland, and Cui Hong — joined

one after another, propelling the research group onto a faster track of development, and things proceeded more smoothly from then on. With Prof. Fang's strong support, many of my junior colleagues went directly abroad to pursue their doctoral degrees. I remained in the lab, continuing to conduct basic research under Prof. Fang's guidance, while also devoting considerable effort to the development of explosive detectors. In 2008, the lab moved from Building 7 to Building 6, and in 2011, from Building 6 to Zhizhi Building on Chang'an Campus; I played a leading role in both moves, helping to complete each relocation of the lab.

By 2011, many of my junior classmates and fellow students were studying abroad, and Yan Ni also went to Georgetown University in the United States in 2010 for a joint training program. Upon completing my PhD, perhaps because my performance had been satisfactory, I was very eager to stay on at the university. At that time, Prof. Xin Yunhong, who had collaborated with us for many years, offered me what now seems like a very good opportunity: a position at the university. When I excitedly shared this news with Prof. Fang and expressed my desire to remain in the lab or serve as a lecturer, Prof. Fang unexpectedly refused outright and even criticized Prof. Xin — something that still weighs heavily on my conscience to this day. Prof. Fang pointed me in a new direction: one must have higher aspirations in life and pursue postdoctoral research. This completely dashed my hopes of staying on as a

lecturer. Seeing that my classmates, who had performed less well than I had — and given that I was the university president's own student — still had opportunities to stay at the university, I couldn't help but feel a sense of injustice. It is only now, many years later, that I fully understand Prof. Fang's well-intentioned decision.

The process of applying for postdoctoral positions was quite challenging. After finally receiving several offers, I reported back to Prof. Fang, who also taught me a new word — since he required us to write to him in English every time. I remember that when I told him about the offers, his first words were, "Don't be silly. Go to Canada." That was the first time I'd ever heard the word "silly". So I made the firm decision to go to Canada to pursue

postdoctoral research.

Time flies. In June 2011, I faced my doctoral dissertation defense. Prof. Fang specially invited Academician Jiang Lei to serve as the chair of my defense committee, which left me both delighted and anxious. Having him preside over the defense was, of course, a recognition of my doctoral work, but it also brought immense pressure. As is well known, Prof. Jiang Lei is an extremely rigorous scientist. On the day of the defense, he posed several profound questions that were truly challenging to answer. Fortunately, I was quite familiar with my dissertation, and in the end, I managed to complete the defense without any major mishaps.

(Part 2 of 3, to be continued)



总策划: 房喻教授

Producer & Editor-in-Chief: Prof. Fang Yu

责任编辑: 刘忠山 冯伟

Executive Editors: Liu Zhongshan, Feng Wei

翻译: 冯伟

Translator: Feng Wei

校对: 团队全体老师

Proofreading: Fang Group teachers

地址: 陕西省西安市长安区西长安街 620 号

陕西师范大学长安校区

Chang'an Campus, Shaanxi Normal University,

620 West Chang'an Avenue, Chang'an District, Xi'an,

Shaanxi, P. R. China

网站 (Website): <https://incsmm.snnu.edu.cn>

电子邮箱 (Email): incsmm@snnu.edu.cn



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