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Editorial

Tsinghua Chemistry Centennial: Honoring the past, shaping the future

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In April 2026, we celebrate the centennial of the Department of Chemistry at Tsinghua University. Since in the founding of Tsinghua University in 1911, the university has upheld its motto, "Self-Discipline and Social Commitment", and remained committed to cultivating talents with both academic excellence and moral integrity, while striving toward the goal of becoming a world-class university. As one of the longest-established departments at Tsinghua University, the Department of Chemistry has always stood at the forefront of chemical education and scientific research in China, making enduring contributions to the nation's scientific and technological progress and to the talent cultivation.

In 1925, "Tsing Hua College" established its university section, and the Department of Chemistry was founded the following year, with Professor Kwang-Pi Yang (杨光弼) serving as its first chair. At the time of its founding, the department had only three professors. In the same year, Chung-Hsi Kao (高崇熙) joined the faculty; in 1928, Tsinghua University was officially renamed "National Tsing Hua University", and Chung-Hsi Kao (高崇熙) succeeded as chair of the Department of Chemistry. In 1929, renowned scholars as Tzu-Kao Chang (张子高), Tzu-Ching Huang (黄子卿), and Peter Pan-Tieh Sah (萨本铁) were recruited. Tzu-Kao Chang (张子高) then assumed the chair, while Chung-Hsi Kao (高崇熙) turned to overseeing the construction of the Chemistry Building. Yunhua Li (李运华) joined in 1930, followed by Ta-Yu Chang (张大煜) in 1933. With a constellation of eminent faculty members, the Department of Chemistry rapidly developed into one of China's leading centers for chemical education and research. A remarkable number of faculties and students of this period and the "Tsing Hua College" era later became the pioneers in chemistry and chemical engineering, including Tzu-Kao Chang (张子高), Te-Pang Hou (侯德榜), Zongyue Qiu (邱宗岳), Chang-Kung Chuang (庄长恭), Shih-Hsien Yang (杨石先), Chao-Lun Tseng (曾昭抡), Tzu-Ching Huang (黄子卿), Ta-Yu Chang (张大煜), Hanqing Yuan (袁翰青), Tsing-Lien Chang (张青莲), Siliang Qian (钱思亮), Chen-Heng Kao (高振衡), Jun Shi (时钧), Dexi Wang (汪德熙), Xinde Feng (冯新德), Xin-Min Chen (陈新民), Chi Wu (武迟), Ben-Xi Cao (曹本熹), Guanrong Chen (陈冠荣), Shizhen Wang (王世真), Yajie Zhu (朱亚杰), Lun Xiao (萧伦), Peiyun Huang (黄培云), and Longxiang Zhang (张龙翔). During this period, the research in the department was also fruitful. For example, Prof. Peter Pan-Tieh Sah (萨本铁) published ten research papers in renowned international chemistry journals, five of them in the *Journal of the American Chemical Society*. The Department also educated outstanding students such as Ping Song (宋平) and Yilin Yao (姚依林), who later became national leaders.

After the *Lugou* Bridge Incident, National Tsing Hua University, National Peking University and Nankai University merged to form Lin-shih-ta-hsueh, which was renamed the National South-West Associated University in 1938 after moving to Kunming. During this period, the Department of Chemistry was chaired by Shih-Hsien Yang (杨石先). Throughout the eight years of the War of Resistance against Japanese Aggression, despite immense hardship, the union of the three universities yielded remarkable accomplishments. The department trained many exceptional talents, among whom Au-Chin Tang (唐敖庆), Binglin He (何炳林), Ruyu Chen (陈茹玉), Panwen Shen (申泮文), Pang Zhang (张滂), Jingyi Niu (钮经义), Chenglu Zou (邹承鲁), and Jiading Wang (汪家鼎) were outstanding representatives.

After victory in the War of Resistance against Japanese Aggression, the University returned to the Tsinghua campus, where the faculty overcame numerous difficulties to resume teaching and research. In 1949, Professor Tsing-Lien Chang (张青莲) achieved outstanding results in heavy-water research, with his work published in *Nature*. In 1950, Professor Chung-Hsi Kao (高崇熙) advanced the synthesis and purification of chemical reagents from the laboratory to industrial production, laying the foundation for what would become the Beijing Xinhua Chemical Reagents Research Institute, the predecessor of the Beijing Chemical Works. During this period, up to the national reorganization of higher education institutions in 1952, the department educated many outstanding students, including Yuyuan Xie (谢毓元), Yongjun Zhu (朱永镕), Jisheng Chen (陈冀胜), Weizu Wu (吴慰祖), Chunhui Huang (黄春辉), Min Wang (王珉), Guangqi Yang (杨光启), Yadong Hu (胡亚东), Nianyi Chen (陈念贻), Xinqi Song (宋心琦), Yuzhi Gong (龚育之), and Chaozhu Ji (冀朝铸), among others.

In the nationwide reorganization of higher education institutions in 1952, the Department of Chemistry at Tsinghua University was merged into the Department of Chemistry at Peking University. With the exception of Professor Tzu-Kao Chang (张子高) and a small number of faculty members who remained at Tsinghua, most teachers and students were transferred to Peking University.

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Thereafter, Tsinghua University established a General Chemistry Teaching and Research Group to undertake the teaching of foundational chemistry courses for the University. In 1958, Tsinghua University established the Department of Engineering Chemistry, and in 1979 it launched an undergraduate science major in "Physical Chemistry and Instrumental Analysis". In 1985, the Department of Chemistry and Chemical Engineering was formally divided into the Department of Chemistry and the Department of Chemical Engineering, marking the reestablishment of the Department of Chemistry.

Over the more than forty years since its reestablishment, the Department of Chemistry has upheld the tradition of "fostering virtue through education and cultivating talent for the nation". It has trained a large number of outstanding individuals capable of shouldering the responsibilities of national rejuvenation. Among its alumni and faculty, those who have gone on to become academicians include Yufen Zhao (赵玉芬), Qi Ouyang (欧阳颀), Xi Zhang (张希), Yadong Li (李亚栋), Yong Qiu (邱勇), Jinghong Li (李景虹), Zhonghua Liu (刘仲华), Meixiang Wang (王梅祥), and Jun Li (李隽).

Today, the Department of Chemistry at Tsinghua University has developed into one of China's foremost centers for chemical research and talent cultivation with well-established international reputation. At present, the department comprises five institutes: Inorganic Chemistry, Organic Chemistry, Analytical Chemistry, Physical Chemistry, and Polymer Chemistry and Physics. It also encompasses five interdisciplinary research directions: Nano- and Materials Chemistry, Chemical Biology, Organic Electronics, Theoretical Chemistry, and Supramolecular Chemistry. In addition, it hosts two Key Laboratories of the Ministry of Education, one Engineering Research Center of the Ministry of Education, and one Center for Basic Molecular Science. Its research covers all major areas of modern chemistry, including fundamental molecular science in chemistry, chemical problems in life processes, new methods and instruments for the analysis of complex samples, organic optoelectronic materials and devices, novel functional crystalline materials, supramolecular self-assembly, and nanostructured materials, among other frontiers. In talent cultivation, the department has consistently advocated the integration of theoretical and practical teaching. Undergraduate students are given a solid foundation, while graduate students directly participate in cutting-edge international research projects, thereby continuously enhancing teaching standards and talent quality. As of 2026, the Department of Chemistry has more than one hundred faculty and staff members, including nine members of the Chinese Academy of Sciences.

According to the U.S. News 2025–2026 Best Global Universities Subject Rankings, Tsinghua University ranks No. 1 in Chemistry worldwide. The Essential Science Indicators (ESI) database shows that Tsinghua Chemistry is among the top 1‰ globally. In scientific innovation, the Department of Chemistry has undertaken a large number of national, provincial, and ministerial research projects and achieved a series of remarkable breakthroughs. Notable accomplishments have been made in areas such as catalysts for renewable energy and environmental protection, the synthesis and properties of functional polymers, and the synthesis of molecular pharmaceuticals and medicine. In the translation of scientific and technological achievements, the department has actively promoted the integration of fundamental research with practical applications, making important contributions to the development of China's liquid-crystal industry. A number of patented technologies have been industrialized; representative examples include OLED-related materials that have progressed from the laboratory to industrial application, supporting the development of China's optoelectronic materials and display industries. Over the past century, the Department of Chemistry at Tsinghua University has brought together generations of leading scientists and has produced an extraordinary number of talented students. Since China established the system of Academicians (known as the members of academic divisions before 1994), 61 faculty members and alumni have become members of the Chinese Academy of Sciences or the Chinese Academy of Engineering, and many others have been elected to academies in Europe, the United States, and other international academic institutions. In scholarly publishing, faculty members of the department have continued to publish high-level research in top international journals such as *Nature*, *Science*, the *Journal of the American Chemical Society*, and *Angewandte Chemie International Edition*, with steadily increasing academic influence. In terms of patents, multiple core technologies have been granted domestic and international invention patents, providing strong support for the development of strategic emerging industries such as clean energy, biomedicine, electronic information, and new materials.

A century of chemistry has passed the torch from generation to generation; building on the past and opening up the future, the department now writes a new chapter. Standing at a new historical starting point, the Department of Chemistry at Tsinghua University will continue to uphold the spirit of the motto "Self-Discipline and Social Commitment", remain anchored to the course of national rejuvenation, serve the nation's pursuit of high-level scientific and technological self-reliance, embrace the world with an even more open posture, and stride toward the future with even greater determination. It will continue to work tirelessly to cultivate more outstanding talent in chemistry, to advance chemical research and education in China, and to build a world-class discipline in chemistry at an early date.

Among the 79 papers included in this invited special issue, there are 23 review articles and 56 research papers, focusing on the latest research achievements in the fields of electrocatalysis and energy conversion, batteries and energy storage, luminescence and optoelectronics, biomedicine and sensing, polymers and soft matter, 2D materials and heterostructures, environment and adsorption, synthesis and manufacturing, and interdisciplinary research.

I. Electrocatalysis and energy conversion

These studies focus on key energy-conversion reactions such as water electrolysis, carbon dioxide reduction, and nitrogen removal, with particular emphasis on the design and mechanistic understanding of frontier material systems including single-atom catalysts, high-entropy alloys, and heterostructures. Their innovations are reflected in several aspects. For the controllable preparation of single-atom catalysts, a one-pot synthetic strategy enabled the highly dispersed anchoring of Ir single atoms on ordered mesoporous carbon, significantly improving the selectivity and stability of low-carbon alkane dehydrogenation. In the area of high-entropy oxides, a surface-entropy regulation strategy was used to synthesize subnanometer high-entropy oxides under mild conditions, greatly enhancing CO_2 photoreduction activity. In heterostructure regulation, a Co_8S_8-Mn_3O_4 heterojunction was

constructed through an electron-injection softening strategy, enabling an almost barrier-free tandem sulfur reduction reaction in lithium-sulfur batteries and significantly suppressing the polysulfide shuttle effect. For seawater electrolysis, a MOF-derived Co_3O_4-RuO_2 heterostructure exhibited outstanding bifunctional catalytic performance in natural seawater. In addition, a bimetallic NiCu nanoalloy realized the coupling of anodic ammonia oxidation and cathodic nitrate reduction, achieving a total-nitrogen-removal Faradaic efficiency as high as 157%, thus opening a new pathway for the application of non-noble-metal catalysts in wastewater treatment.

II. Batteries and energy storage

These studies center on high-energy-density storage systems such as lithium-sulfur batteries, lithium-metal batteries, and magnesium-ion batteries, and they address key bottlenecks including polysulfide shuttling, lithium dendrite growth, and sluggish Mg^{2+} diffusion kinetics. Their innovations are reflected in the following aspects. In lithium-sulfur batteries, the construction of a defective Zn_2SnO_{4-x}/SnO_{2-x} heterostructure simultaneously enhanced polysulfide adsorption-catalytic conversion and regulated uniform lithium-ion distribution, thereby maintaining excellent cycling stability even at high sulfur loading. In lithium-metal batteries, a gel polymer electrolyte with both self-healing and recyclability was developed on the basis of a dynamic covalent network in an epoxy-based vitrimer, significantly improving interfacial stability and cycle life. In magnesium-ion batteries, a sulfur-vacancy-rich $VS_4@Bi_2S_3$ heterostructure was constructed through microwave-assisted synthesis; the built-in interfacial electric field significantly lowered the Mg^{2+} diffusion energy barrier, enabling the synergistic improvement of high capacity and long cycling life. In addition, xylan-derived carbon nanosheets with hierarchical porous structures constructed through N/S co-doping greatly improved ion-transport kinetics in supercapacitors.

III. Luminescent materials and optoelectronic devices

These studies have achieved multiple breakthroughs in areas such as perovskite light-emitting diodes, quantum dots, and upconversion luminescence. Their innovations are reflected in several respects. For perovskite LEDs, an intermediate-state stabilization strategy enabled antisolvent-free crystallization and produced a uniform distribution of quantum-well thicknesses. Functional layers prepared entirely by solution processing reduced material costs by 82% and shortened processing time by 90% compared with conventional vacuum deposition. For chiral quantum dots, the design of amino-acid ligands modified with long alkyl chains enabled, for the first time, the synthesis of lipophilic chalcogenide chiral quantum dots, together with size-dependent regulation of circular dichroism signals. In upconversion luminescence, a charge self-compensation strategy reduced cation vacancies induced by rare-earth doping, increasing the emission intensity of CaF_2:Yb,Er by 3.2 times; resin encapsulation further enabled stability for more than six months. In photo-switching materials, a bimetallic halide based on $Sc(DMSO)_6SbCl_6$ realized solvent-driven rewritable information storage with a response time of only a few seconds.

IV. Biomedicine and sensing

These studies demonstrate the unique value of nanomaterials in disease diagnosis, drug delivery, tissue repair, and related directions. Their innovations are reflected in several aspects. In cancer diagnosis, an electrochemical aptasensor based on two-dimensional high-entropy alloy nanosheets was prepared. In immunotherapy, a carrier-free self-assembled nanovaccine was developed; through cathepsin B-responsive release of a STING agonist and antigen peptides, it achieved precise immune activation and efficient antigen presentation. In tissue repair, a hemostatic sponge based on tussah-silk nanofibers and hyaluronic acid realized ultrafast blood absorption and platelet capture through the regulation of pore structure, significantly reducing blood loss in animal experiments. For spinal cord injury repair, an injectable self-healing hydrogel was designed with the combined functions of immune microenvironment remodeling, reactive oxygen species scavenging, and sustained drug release, significantly promoting the recovery of motor function in rats. For antibiotic detection, Fe_3O_4, PCN-222, and a molecularly imprinted polymer were integrated to realize highly selective enrichment and colorimetric detection of sulfamethoxazole.

V. Polymers and soft matter

These studies focus on the molecular design and functional integration of intelligent soft materials such as deep-eutectic gels, self-healing hydrogels, and vitrimer-like polymers. Their innovations are reflected in several respects. For deep-eutectic gels, three gel-construction strategies based on deep eutectic solvents were systematically summarized, and the structure-property relationships between microstructure and macroscopic performance were clarified, providing a new platform for flexible electronics, biomedicine, and related fields. For piezoionic materials, the mechanism of mechano-ionic coupling was elucidated, and the net ionic flux was significantly enhanced through strategies such as interfacial engineering and phase-separation regulation, thereby enabling biomimetic sensing and biointerface signal transduction. For self-healing hydrogels, the introduction of functional nanomaterials such as polydopamine and carbon dots endowed the materials with multiple functions including conductivity, magnetism, and adhesion while preserving their self-healing properties, thereby broadening their applications in wound dressings, tissue engineering, and soft electronics. For flame-retardant materials, ethylenediamine-intercalated black phosphorus nanosheets were used to construct a phosphorus-nitrogen synergistic flame-retardant system while maintaining mechanical performance. For vitrimer-like polymers, nanocomposites with high mechanical strength, self-healing capability, and recyclability were developed on the basis of dynamic covalent epoxy networks, offering a new paradigm for sustainable high-performance materials.

VI. 2D materials and heterostructures

These studies focus on the controllable preparation and functional integration of two-dimensional materials such as boron nitride, transition-metal sulfides, and topological insulators. Their innovations are reflected in several aspects. For boron nitride nanosheets, a scalable preparation route yielding nanosheets with high aspect ratio and high productivity was achieved through a

synergistic exfoliation strategy combining polymer anchoring and thin-layer-confined shearing. In photodetection, a flexible MnSe/a-In_2Se_3 p-n heterojunction was constructed, and strain-regulated photoresponse was realized by exploiting the piezophototronic effect; at a tensile strain of 0.303%, the photoresponsivity increased by 203.9%, and on this basis a vision-tactile fused sensing system was developed. In catalytic imaging, the combined use of multiresolution electrochemiluminescence, photoluminescence, and STEM established for the first time the distinct contribution mechanisms of molybdenum vacancies (V_{Mo}) and sulfur vacancies (V_S) in MoS_2 toward electrocatalytic and photoelectrocatalytic oxygen evolution reactions. In microwave absorption, the defect structure of the $MnBi_2Te_4$ topological insulator was regulated through a progressive oxygen-doping strategy.

VII. Environment and adsorption

These studies address environmental hot issues such as atmospheric water harvesting, fluoride removal, and nanoplastic detection. Their innovations are reflected in several aspects. For atmospheric water harvesting, MOF-303 was grown *in situ* within porous polyacrylate spheres, achieving high loading, high adsorption capacity, and no attenuation in cyclic performance. For fluoride adsorption, crystal-facet engineering of CeO_2 nanocrystals revealed the highly efficient adsorption mechanism of the (111) facet for perfluorooctanoic acid, namely unsaturated Ce(IV) Lewis acid sites, and the preferential adsorption mechanism of the (110) facet for F-, namely the filling of oxygen vacancies, thereby providing theoretical guidance for the design of fluorine-selective materials. For nanoplastic detection, the latest advances in mass spectrometry, spectroscopy, and microscopy combined with machine learning and microfluidics were systematically reviewed, and a performance-evaluation framework was proposed along four capability dimensions: high-throughput quantification, polymer identification, spatial imaging, and *in situ* analysis. For adsorption simulation, the HULU Python package was developed, achieving for the first time grand canonical Monte Carlo simulation based on machine-learning potentials and enabling the efficient prediction of full adsorption isotherms and Henry's constants for porous materials, thereby advancing high-throughput materials screening.

VIII. Synthesis and manufacturing

These studies have achieved breakthrough progress in the controllable preparation and large-scale manufacturing of nanomaterials. Their innovations are reflected in several aspects. For nickel nanoparticles, triethanolamine was used as a regulator, and a mild aqueous reduction strategy decoupled nucleation from growth, enabling precise control of particle size in the range of 95–270 nm and revealing the correlations between particle size, electrical conductivity, and magnetic properties. In microwave-assisted synthesis, dye-predoped monomer emulsions were used as precursors; through systematic regulation of salt concentration, surfactants, dye type, and loading, the size of fluorescent polymer nanoparticles, ranging from tens to hundreds of nanometers, as well as their emission wavelength and brightness, were precisely controlled, and thermal responsiveness was imparted to them. In wet spinning, poly(p-phenylene benzobisoxazole) (PBO) nanofibers were introduced to enhance the interfacial interactions between carbon-nanotube fibers and molecular chains. In micro/nano 3D printing, progress in multimaterial additive manufacturing based on technologies such as photopolymerization, extrusion, and powder-bed fusion was systematically reviewed. The potential of strategies including template mediation and directed assembly of nanoparticles for realizing voxel-level design with "arbitrary materials" was analyzed, and their application prospects in optical devices, microrobots, and related fields were discussed.

IX. Other interdisciplinary fields

These studies span multiple frontier directions, including molecular electronics, plastic degradation, and anticancer drugs, demonstrating the cross-disciplinary innovation potential of nanoscience. Their innovations are reflected in several respects. In molecular electronics, halogenated derivatives with fully conjugated triphenyl-diacetylene backbones were designed to construct metal-self-assembled monolayer-liquid metal electrode molecular junctions, revealing that the pinning effect of the pi-conjugated backbone imposes significant constraints on halogen-substituent regulation of molecular energy levels and coupling strength. In plastic degradation, inspired by the binuclear active sites of metalloenzymes, M_2N_6@C bimetallic catalysts (M = Fe, Co, Ni, Cu, and Zn) were designed; DFT and MD simulations revealed a unified five-step mechanism for the hydrolytic degradation of PET and PU and established a direct correlation among metal spacing, spin state, and substrate selectivity. For anticancer gold-based drugs, the research progress of Au(I), Au(III) complexes and gold clusters was systematically reviewed, with emphasis on the ligand design and structure-activity relationships of Au(I) complexes, the synthetic strategies and anticancer mechanisms of Au(III) complexes, and the enhanced permeability and retention effect and photothermal/photodynamic synergistic therapeutic potential of gold-cluster drugs. In bacterial collective behavior, single-cell and nanoscale tracer techniques were used for the first time to reveal the multistage self-organized evolutionary patterns within Bacillus subtilis microcolonies. It was found that even in the highly crowded late stage, large numbers of bacteria still maintained superdiffusive motion, and it was confirmed that bacterial activity generates intercellular flow fields through passive fluid nanotracers, thereby mediating collective cooperative behavior.