ADVANCING CHEMICAL ENGINEERING EDUCATION

Chemical engineering and technologies are key to building a better world. **MA XINBIN, DEAN AT TIANJIN UNIVERSITY'S School of Chemical Engineering and Technology** (SCET) outlines how the school's academic programmes make a significant contribution.

WHAT IS SCET'S MISSION?

We are committed to training excellent students, producing first-class research results, and contributing to national development. With these goals, we have promoted higher education reform in chemical engineering, gathered top-notch faculty members to promote technological innovation, and broadened international collaboration. We have also driven the development of the chemical engineering industry.

HOW DID SCET BUILD ACADEMIC STRENGTH THROUGHOUT ITS LONG HISTORY?

During its 125-year history, Tianjin University has been home to many generations of academic leaders, and a cradle for student training. As early as the 1920s, Peiyang University, the predecessor of Tianjin University, constructed a lecture hall for industrial chemistry, which attracted renowned chemical engineering experts including Hou Tepang and later, Ding Xuhuai to work with us. This built a solid foundation for our academic programmes and for talents training in chemical engineering. During the nationwide university restructuring in 1952, the merge of chemical engineering departments of seven prestigious universities gathered a group of experts in the field, as well as young talents in Tianjin, further strengthening our status. In the 1980s, our push to drive industry development via academia-industry collaboration led to our rapid development. From 2003 to 2017, SCET consistently ranked number one in evaluations of chemical engineering and technology disciplines by the Ministry of Education of China. In 2017, we were selected for the national 'double first-class' initiative, marking a new chapter of development.

WHAT MAKES SCET SUCH A FINE CHEMICAL ENGINEERING TRAINING PROGRAMME?

As one of the first two Asian schools, and the first in China, to have achieved the Master Level accreditation by the Institution of Chemical Engineers (IChemE), we boast strong international acclaim. Our graduates become internationally certified highly competitive chemical engineers.

SCET takes pride in educating world-class engineers who are committed to achieving technical excellence and seeking answers from facts.

A curriculum system was established accordingly to focus on students' problem-solving capabilities. We have also set up an educational platform integrating enterprise practicum, engineering skill training, research, academic contests, and entrepreneurship, supported by our advanced teaching facilities. Our students have won multiple prizes in national and global contests, including the AIChE Outstanding Student Chapter award.


Ma Xinbin, dean of SCET

Our leadership role in chemical engineering education is also demonstrated in a partnership with other prestigious Chinese universities designed to improve curriculum development and training for the field. The guidelines and accreditation systems we set for professional training are recognized with national awards.

The broadening of chemical engineering education signifies the new growth of SCET. To date, we have attracted international students from more than 50 countries in six continents, who bring in fresh energy to SCET's programmes, enhancing our globalization and diversity.

HOW DO YOU ENHANCE YOUR PROGRAMME VIA COLLABORATION?

An open attitude is key to building a world-class programme in chemical engineering. We have established partnerships with world-renowned universities and research institutions, including the University of Edinburgh, and the University of California, Berkeley. These have allowed for student exchanges, making our training programme more global. Our network also extends to international companies such as Clariant and AstraZeneca, with collaboration bases established for research project cooperation and student internship. We have also organized international conferences that attracted world-class experts. These collaborations promote knowledge and cultural exchange. ■

INNOVATING FOR SUCCESS

Chemical engineers at Tianjin University have fostered cross-disciplinary growth to transform results into productivity.

Driving technological innovation is a mission of today's universities. Tianjin University's School of Chemical Engineering and Technology (SCET) is exploring innovation in frontier fields. Through industry-academia collaborations, it is accelerating coordinated innovation of knowledge, technologies, products and industry, transforming research results to productivity, and driving economic growth.

BOOSTING CHEMICAL ENGINEERING

Distillation, one of the most common separation techniques, has been widely used from oil refining to bulk chemicals. As a key technology for the process industry, it is a priority at SCET. Housing four national platforms on distillation technologies, SCET is well positioned for breakthroughs in the field, including developing China's largest distillation columns.

Integrating separation theories, fluid dynamics, and process analysis and optimization methods, SCET researchers have developed technologies for large-scale packings and trays, the core of distillation columns. Packings are ideal for handling a wide range of gas and liquid flow rates, while trays are typically used in vacuum distillation. Various visualization technologies are also used in the design and optimization of internals for large-scale distillation equipment. The resulting columns enable doubling of distillation capacity to 10 million tonnes annually, and are widely used in China's large-scale oil-refining plants.

SCET researchers have also developed energy-saving techniques and enhanced integration technologies for reactive distillation, which have been used in industry. Their oil quench systems have been used widely in large-scale ethylene processing plants. Meanwhile, based on non-metal foam materials with porous media, they have designed novel internals for gas and liquid mass transfer, and built theoretical models for distillation processes, leading to use of their foam material mass transfer units in polyester, oil refining, polysilicon, and air separation industries.

Crystallization processes are also studied at SCET, home to the National Engineering and Technology Research Center for Industrial Crystallization, the only national-level incubation base in the field.

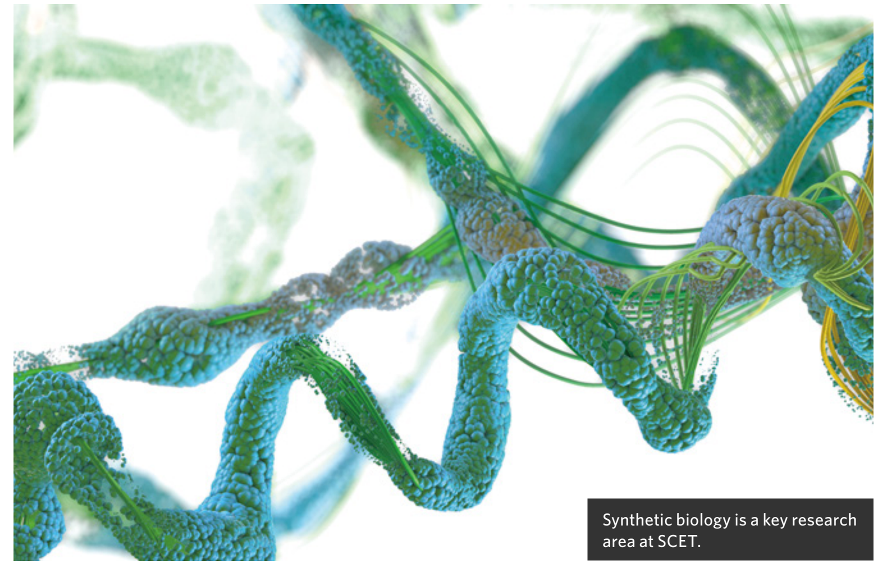
To support the development of high-end functional crystal products and materials in medicine, food, and other industries, researchers have studied crystallization mechanisms, system engineering, and industrialization processes, leading to improved technologies and equipment. The centre also provides engineering services from research and development to design and commercialization. Its technologies and equipment are used nationwide, bringing in output value of more than 1.23 billion yuan per year. These technologies are recognized by several national and provincial science and technology awards.

Economic benefits have also flowed from propane dehydrogenation technologies for producing propylene, a common raw material used in film packaging, automotive and textile industries. Catalysts developed at SCET can achieve 40%-plus propylene yield, while their new techniques can reduce system energy consumption by 30%. These low-carbon alkane conversion and utilization technologies are being used in petroleum enterprises, leading the field in energy-efficient chemical engineering.

SCET at Tianjin University

ADVERTISEMENT FEATURE

This ethylene plant operated by SINOPEC Fujian Petrochemical Company, using SCET technologies, achieves an annual yield of 800,000 tonnes. Its oil quench tower has a packed column with a 11.5-metre diameter, the largest in China.



Synthetic biology is a key research area at SCET.

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Sustainable chemical processing is best illustrated in SCET's research on clean coal conversion into bulk chemicals. Producing ethylene glycol, a raw material for polyester fibres and antifreeze formulations, from syngas, requires an integrated technology including the coupling of CO with methanol and the subsequent hydrogenation. Focusing on this technology, SCET's fundamental and applied studies cover the spectrum from reaction kinetics, to catalyst design and system integration. The efficient, stable and robust palladium-based catalyst invented at SCET reduces the amount of palladium use by 80%, bringing down catalyst cost by 60%.

The team has also invented technology for large-scale preparation of a copper-based catalyst for hydrogenation of dimethyl oxalate to ethylene glycol, significantly enhancing its selectivity and stability. Their technologies for syngas to ethylene glycol process have enabled clean and stable long-term operation of industrial plants. The diverse solutions to transform syngas into high value-added products, like oxalic acid, carbonate, and ethanol, have employed the use of industrial exhaust gas, contributing to emission reduction and efficiency enhancement for chemical engineering enterprises. SCET has won multiple international and domestic invention patents for these results.

NEW FRONTIERS FOR TECHNOLOGY TRANSFER

Chemical compounds, such as ethanol and vinyl acetate, can also be produced from biomass. As a pioneer of biomass conversion research in China, SCET is harnessing technologies to support the development of biomass energy. A 200,000 MTA fuel ethanol plant was set up using SCET's advanced technology to manufacture bio-ethanol from cassava cultivated on barren land. It is one of the world's largest commercial plants of its kind. The project won the second prize of the National Science and Technology Progress award, and the World Intellectual Property Organization (WIPO) gold award. The team also built a platform for production of various chemicals from bio-ethanol, based on which, they have also developed techniques using biomass as a raw material to produce vinyl acetate. The technology led to the world's first production plant capable of an annual output of 50,000 tonnes of ethylene and 100,000 tonnes of vinyl acetate yielded from biomass materials.

Apart from making use of biomass for energy products, SCET also established the Frontier Science Centre for Synthetic Biology in 2018 to promote commercialization of synthetic biology technologies and support innovation in bioindustry. Sponsored by the Ministry of Education, the centre focuses on issues like genome synthesis, and construction of cell factories.

Specific research focuses include synthetic genomics, such as genome design, and chemical synthesis and assembly to enable high-throughput and low-cost DNA synthesis; design and construction of artificial cells, including intelligent design of metabolic networks, and automated assembly of functional pathways to enable cell factory construction for pharmaceuticals, chemical products and energy materials; photoelectric-driven artificial synthesis systems, which harness light and electricity power to achieve biosynthesis and mass transformation; and new theories and technologies of synthetic biology for DNA information storage, drug preparation, and drug delivery.

SCET researchers have developed biodegradable and bio-compatible materials for biomedical use. These include hydrogels based on nucleic acid molecules, nano compounds, and nanorobots that can be used for delivering stem cells in gene therapy; polymer nano carriers for drug delivery in cancer treatment; protein-based heart stent materials; and a novel material for artificial islets that can shield cells from the immune system.

BETTER MATERIALS FOR INDUSTRIAL USE

Materials innovations at SCET also include the development of high-performance membranes for water purification, olefin-paraffin separation, and carbon capture. The team brought a philosophy of biomimetism and bioinspiration to membrane processes, developing novel pathways and platforms for materials design and fabrication, structure and microenvironment manipulation, and mass transport. SCET invented surface segregation methods for preparing antifouling membranes, and bioinspired methods for hybrid and composite membrane preparation, for which they built a large-scale production line. They conducted pivotal work in organic framework membrane preparation and use. Their new theories for suppressing membrane fouling end the trade-off between permeability and selectivity.

Based on studies in structure-performance relationship, SCET has proposed ways to allow for multiple selections in hierarchical membrane structures, enabling preferential adsorption, and the permeation of large molecules over smaller ones.

Frequently used in seawater desalination, thin-film-composite reverse osmosis membranes can be degraded by biofoulants and free chlorine oxidation. SCET discovered that a hydantoin derivative, grafted on the membrane surfaces, could make them chlorine-resistant and sterile. Large-scale production of such membranes, through a combination of secondary interfacial polymerization, free radical grafting, and physical coating, has led to great success.

Organic photoelectronic materials, widely used in photoelectronic convertors, form another new materials research focus at SCET. For years, a team has been studying the synthesis, purification and crystal form regulation methods of metal phthalocyanine nano-materials, as well as their photoconductive performance in laser organic photoconductors. The resulting materials have excellent photosensitivity, and use in laser printers and copiers by major brands.

Harnessing high photoelectric conversion capability of nanomaterials, SCET researchers developed a flexible photodetector with high near-infrared responsiveness (660-800nm), and large-area, stable film crystals of perovskite for self-driven photoelectric sensors.

The research on molecular design, synthesis and application technologies for high-mobility hole and electron transport has led to the development of printing technology for organic electroluminescent displays, and improvement in the functional film printing process. Their inventions also include printable luminescent inks.

FOCUS ON GREEN ENERGY RESEARCH

SCET's commitment to sustainability is illustrated in its research on new energy materials and technologies. Researchers have improved storage and catalytic reaction for Li-S batteries, a popular alternative to Li-ion batteries. They led the use of catalysis to tackle the 'shuttle effect' of soluble polysulfide, which causes lithium corrosion, capacity fading and excess use of electrolytes, lowering energy efficiency with a prolonged charge process. The study is on the way to remove a roadblock to the application and commercialization of Li-S batteries. Researchers have also improved volumetric energy densities of compact batteries and supercapacitors. They proposed the capillary densification strategy of graphene and nanomaterials towards highly dense electrodes. The high volumetric energy density supercapacitors and Li-ion batteries they produced are important for developing electric vehicles and portable devices that require energy storage in a limited space.

Another example is the study of electrochemical CO_2 reduction to close the carbon loop. SCET researchers have designed high-efficiency electro-catalysts, and used solar power to reduce CO_2 to value-added products. To enhance the cleavage of CO_2 bonds, the surface structure of the catalyst was designed to accelerate adsorption and activation. By adjusting the concentration and type of adsorbents on the catalyst surface, the selectivity and stability of the CO_2 reduction catalyst were enhanced. They have also found ways to boost the conversion of CO_2 to methanol and multi-carbon products. This progress in electrocatalytic CO_2 reduction has led to the development of efficient artificial photosynthesis, enabling 'green' transformation of CO_2 to gas and liquid fuels. ■

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