ADVERTISEMENT FEATURE

A hub for chemical engineers

A MATURING PLATFORM for interdisciplinary chemical engineering research at Nanjing Tech University

Nanjing Tech University's Jiangpu campus.

The paper pulp waste water processing plant achieves zero pollution discharge.

The Materials-Oriented
Chemical Engineering (MCE) laboratory at Nanjing Tech University was officially authorized as a State Key Laboratory by China's Ministry of Science and Technology in 2007. The laboratory, which is home to three members of the Chinese Academy of Engineering, is devoted to frontier research in chemical engineering and materials science to meet the scientific challenges and needs of China's technological advancement.

From developing a high-performance ecologically friendly cement, and a green method for processing industrial waste, through to their domination of China's ceramic membrane market, MCE's research teams are conducting chemical engineering research that is both environmentally and commercially significant.

A MATERIALS ORIENTED APPROACH TO RESEARCH

MCE's membrane material and process team is focussed on addressing the high energy consumption and low efficiency of materials separation in industrial processing. The team, led by Professor Nanping Xu, a member of the Chinese Academy of Engineering, and Professor Weihong Xing, has developed eight membrane products, including porous ceramic membranes, zeolite membranes, and PVDF polymeric membranes, that have been successfully commercialized. The team's ceramic membrane products dominate 60% of the domestic market, and its zeolite membranes have been used in more than 200 chemical engineering projects for industrial solvent dehydration. The researchers have also developed a continuous membrane reactor, a key technology for liquid phase reactions containing ultrafine catalysts in the petroleum industry, and their integrated membrane technology has helped realize zero-pollutant discharge from waste water from a paper mill plant.

"The team is producing world-leading research in membrane science and technology and has made significant contribution to the membrane industry," acknowledged Enrico Drioli, honorary chairman of the European Membrane Society.

The bio-based materials team, led by Professor Pingkai Ouyang, also a member of the Chinese Academy of Engineering, is guided by China's strategy of substituting biomaterials for petroleum to alleviate its dependence on fossil resources. They use modern chemical engineering methods to solve several key problems in the preparation of biomaterials to propel China's processing technology to an international level. This includes the production of biopolymers such as γ-polyglutamic acid (γ-PGA), which has been successfully used in fertilizer. A sixth of all synergistic fertilizer in China now uses γ-PGA products from MCE. The laboratory has also set up the world's largest and most technologically advanced yeast-nucleic acid-nucleotide manufacturing facility and is focused on producing biofuels from renewable resources such as waste plastics.

To establish a theoretical foundation for materials-oriented chemical engineering, the surfaces and interfaces team, led by Professor Xiaohua Lu and Professor Wanqin Jin, conducts experimental research on materials of different size scales, using molecular simulation and design methods to reveal the relationship between material structure, performance, and processing behaviour. For example, the team used confined mass transport theory to interpret the unprecedented molecular separation properties achieved in two-dimensional-materials membranes with sub-nanosized interlayer channels.

The materials and process integration team at MCE is led by Professor Xu Qiao. Their research is focussed on green chemical engineering technology. They have developed several atom-economic reaction routes to produce esters, benzaldehyde, and diphenylamine, and have built a diphenylamine plant with a production capacity of 45 kilotonnes per year and a chlorobenzaldehyde plant with a production capacity of 12 kilotonnes per year. The team is also working on reaction-separation integrated processes, and purification of industrial wastes through oxycracking. So far, the cumulative reduction of waste gas and organic hazardous waste, due to their efforts, is more than 672 million cubic metres and approximately 10,000 tonnes, respectively.

The Cement Materials team, led by Professor Mingshu Tang, a member of the Chinese Academy of Engineering, and Professor Zhongzi Xu, addresses the high resource consumption rate and low utilization efficiency in cement production. They have developed a new cement material system that is ecologically friendly and has excellent strength and durability. For example, they prepared a low-carbon blended cement by replacing the cement clinker with up to 60% various industrial waste products including fly ash and slag. At 28 days, the cement had a compressive strength of 50MPa, a stable volume and a high resistance to shrinkage cracking.

To optimize China's energy structure, the MCE energy materials team, led by Zongping Shao, has developed new technologies to improve energy production and utilization efficiency, such as low-cost perovskite-based materials for solid oxide fuel cells, metal-air batteries, and electrolysis of water. The team has also overcome key challenges in the production of new materials for low temperature solid oxide fuel cells and commercialized reduced-platinum electrocatalysts for proton-exchange membrane fuel cells (PEMFC).

A DECADE OF ACCOMPLISHMENT

After more than a decade of development, MCE has become a formidable force in the chemical engineering field. It has undertaken a number of national-level major projects including two projects of the National Natural Science Foundation of China, and five projects of the National Basic Research Program of China (973 Program).

MCE has made major contributions to the development of chemical engineering of Nanjing Tech, which was selected as the first batch of national first-level key disciplines. In the Global Ranking of Academic Subjects 2020 for Chemical Engineering, Nanjing Tech University was ranked 32nd in the world.

MCE staff have published more than 4,000 SCI papers in journals such as *Nature*; authorized more than 1,000 Chinese invention patents and nearly 50 international invention patents; formulated five national standards; won eight national science and technology awards (National Natural Science Award, National Technology Invention Award and National Science and Technology Progress Award), and incubated a dozen companies.

The materials-oriented technologies developed by MCE have had a significant impact on a domestic and international level. The laboratory continues to contribute to China's technological development, economy and national security. MCE is also internationally renowned, as noted by Keith Gubbins, Fellow of the American Academy of Engineering, "The State Key Laboratory of Materials-Oriented Chemical Engineering has an excellent reputation and global impact," Gubbins says. ■

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