

ANSO Outreach is a new publication of ANSO promoting effective technology transfer from research to innovation, from demonstration to market. All the products presented in ANSO Outreach are focused on improving the quality of life and well-being of people all over the world by following the principle of practical, low-cost and user-friendly technologies. We also aim to further strengthen international cooperation on Science, Technology, Innovation and Capacity Building (STIC) by sharing advanced technologies and new products with ANSO members and partners.



中国科学院大连化学物理研究所
DALIAN INSTITUTE OF CHEMICAL PHYSICS, CHINESE ACADEMY OF SCIENCES



Introduction to DICP

Products Directory

- 1 The Green Manufacturing Technology of Oligosaccharides and Its Implication
寡糖绿色制造及功能产品开发应用 P2
- 2 Advanced Technology for Production of 1,3- Propanediol
关键聚合单体1,3-丙二醇生产技术 P5
- 3 The Technology of Methanol to Ethanol
甲醇制乙醇技术 P8
- 4 Grid-scale Vanadium Flow Battery Energy Storage Technology
大规模全钒液流电池储能技术 P10
- 5 Higher Alcohol Synthesis Technology from Syngas
合成气制高碳醇技术 P12
- 6 Heterogeneous Hydroformylation Technology
多相氢甲酰化技术 P14
- 7 Multiple Pesticides Rapid Detection Technology
多种类农残快速检测技术 P16
- 8 Polytetrafluoroethylene (PTFE) Hollow Fiber Membrane Contactor Technology
聚四氟乙烯中空纤维膜接触器技术 P18

The Dalian Institute of Chemical Physics (DICP) of Chinese Academy of Sciences (CAS) is located in the beautiful coastal city of Dalian, China. Since its founding in 1949, DICP has built up an impressive portfolio of achievements in basic and applied sciences that have supported technological and economic development. Traditionally, fields of excellence of DICP include catalysis, chemical engineering, chemical lasers, molecular reaction dynamics, organic synthesis, modern chromatographic techniques and biotechnology.

DICP is composed of 22 laboratories with unique research approaches and imperatives. While possessing distinct and diverse capabilities, technologies and facilities, all laboratories can work in unison to fulfill various important tasks, programs and projects.

At present, there are 1,500 staff and post-doctoral fellows, and 1,400 graduate students in DICP, with 26 members of the Chinese Academy of Sciences (CAS) and Chinese Academy of Engineering (CAE). Many outstanding scientists and engineers have chosen the institute as a home base where they can develop strong skills and enhance their domestic and international visibility through papers and technological innovation.

DICP has developed a large number of valuable technologies for industry. In the past 15 years, DICP has been granted more than 2,000 patents, which is ranked at the top of all CAS institutes. The DICP faculty have gained more than 93 national awards and 230 provincial-level awards, including the National Supreme Science and Technology Award, which was awarded to Professor ZHANG Cunhao in 2014.

Brief Introduction

Oligosaccharides are carbohydrates made up of 2-10 mono-saccharide residues connected by glycosidic bonds. They have a variety of biological activities and are widely used in the fields of medicine, food, pesticides, fertilizers, and feed additives. Oligosaccharides can be obtained by degrading natural polysaccharides that are widely and abundantly present in nature. The green manufacturing technology of oligosaccharides is to develop a series of polysaccharide degrading enzymes, and combine the enzymatic reaction with the subsequent product separation technology, so as to realize an efficient large-scale production process of oligosaccharides with a controllable degree of polymerization (DP). This technology realizes an efficient large-scale production process of oligosaccharides with a controllable DP, and overcomes the bottleneck problem of oligosaccharide preparation and quality control. At present, the application of this technology has realized the large-scale, continuous and clean production

of chitosan oligosaccharides, alginate oligosaccharides and pectin oligosaccharides. This technology can be applied to the high-value utilization of polysaccharide biomass resources.

The oligosaccharide biological pesticides and fertilizers have the advantages of improving disease and stress resistance, increasing crop yields and quality, and the preservation of freshness with low dosage. Moreover, they do not cause pathogenic microbes to develop resistance. They are environment friendly and have a broad-spectrum of application. Oligosaccharide feed additives can significantly improve the growth of livestock and poultry, the quality of meat, and reduce mortality. They are green feed additives with high efficiency that can partially replace antibiotics. Oligosaccharide functional foods are reported to be able to regulate human immunity and intestinal health. The application of it can realize both socio-economic and ecological benefits.



Figure 1. Thousand tons/year oligosaccharide enzymatic process production device

Technical Parameters

- Polysaccharide degrading enzyme activity should be higher than 20000 U/g, and the enzyme activity should remain above 90% after storage at 4°C for 3 months. The reaction temperature of the enzymatic process should be lower than 50°C.
- The yield of oligosaccharides should higher than 90%, and the content of monosaccharides should less than 5%. The product polymerization degree distribution should between 2

and 10, and the quality should be stable and controllable.

- The effectiveness of oligosaccharide agricultural preparations on crop-disease prevention should reach 50%-90%, the crop yield should be increased by 10%-30%, and the use of chemical pesticides and fertilizers should be reduced by 20%-30%.

Technical Advantages

- The raw material to produce oligosaccharides is natural polysaccharides, which are renewable resources. The waste from polysaccharide processing in agricultural and food industries can be used as the raw materials as well. Its production process is low cost, low-carbon emission, and environment friendly.
- The key technology, polysaccharide degrading enzymes, ensures the green and high-efficiency of oligosaccharide preparation. Therefore, high-quality oligosaccharide products can be obtained under the condition of low investment and operating cost. The DP of the produced oligosaccharide is controllable, the quality is stable, and its biological activity is high. In addition, the application technology of the functional products is well established.
- The oligosaccharide agricultural preparations have a broad-spectrum of applications and high-efficiency. They have a long-lasting effect and do not cause pathogenic microorganisms to develop drug resistance. Oligosaccharides are green and environment friendly. Used in combination with conventional pesticides, the amount of pesticides can be reduced.



Figure 2. Oligosaccharide functional products

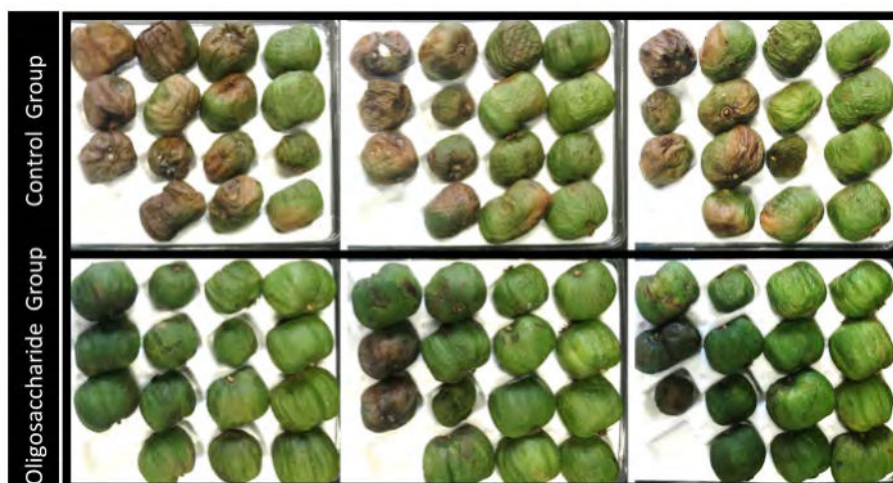


Figure 3. Fresh-keeping application of oligosaccharide agricultural preparations (Kiwi berry fruit stored at 4 degrees for 7 weeks)

Cooperation Models

Can provide or develop polysaccharide degrading enzymes, complete system of enzymatic processes, oligosaccharide functional products, or provide application technical services such as green planting technology with oligosaccharide functional products as the core.

- ☒ Product sales
- ☒ Technology licensing or transfer
- ☒ Technology development

Potential Market

- This technology could be used in the development of oligosaccharide fertilizer preparations, feed additives, and functional foods.
- Green planting based on oligosaccharide pesticides, fertilizers and other green agricultural preparations.
- Green breeding of livestock, poultry and aquatic animals based on oligosaccharide feed additives.
- Oligosaccharide functional food benefits to human health.

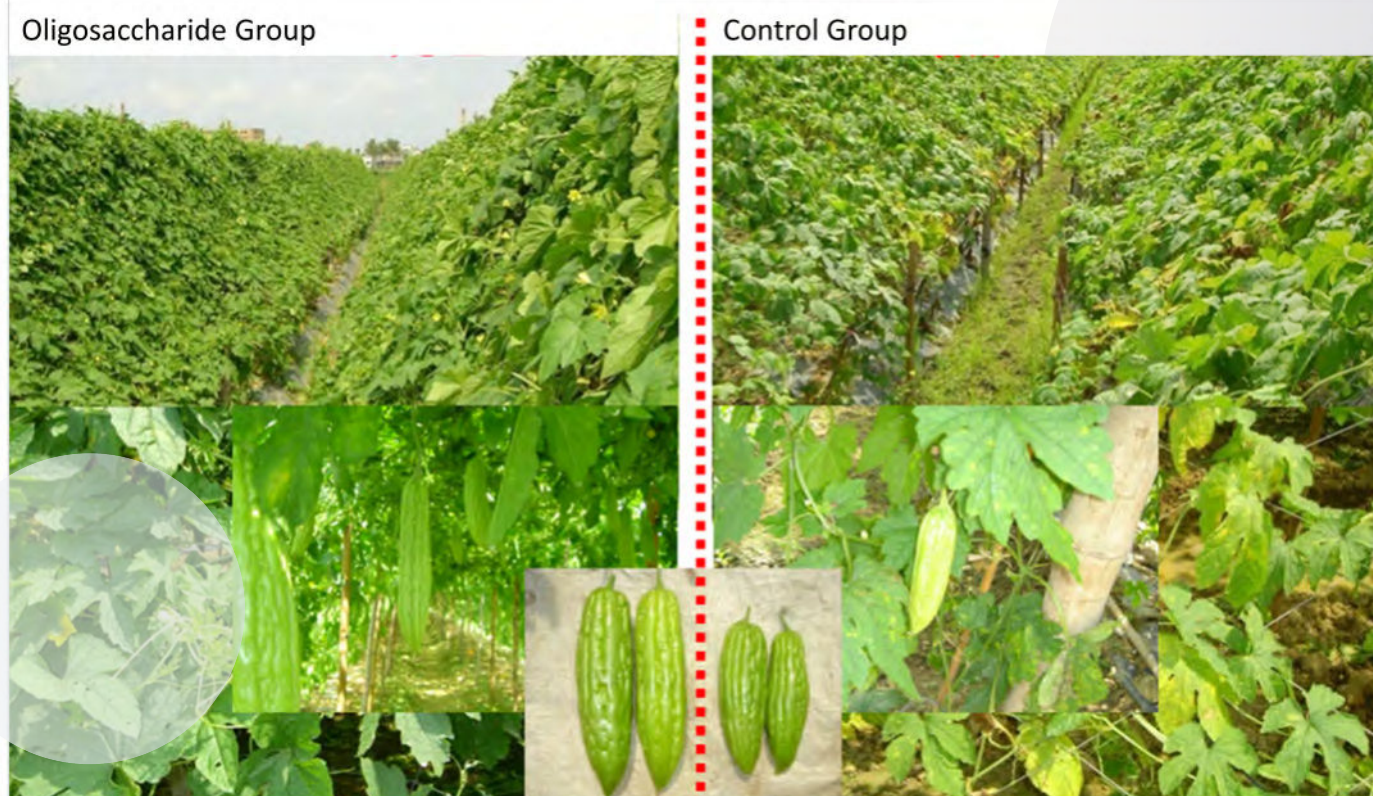


Figure 4. Field application of oligosaccharide agricultural preparations (balsam pear)



**Lead
Scientist**

YIN Heng PhD, Professor

Prof. YIN's research interests include glyco-engineering and enzyme engineering, plant immunity and glycobiology. His research focuses on the utilization of polysaccharide biomass resources in nature, which mainly includes two aspects: the mining and creation of polysaccharide degradation enzymes and efficient degradation of polysaccharides; the functions and mechanisms of oligosaccharides especially the regulation of plant immunity by oligosaccharides. He was awarded the Liaoning Revitalization Talents, the Outstanding Member of the Youth Association of the CAS.

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Brief Introduction

1,3-propanediol (1,3-PDO) is an important raw material widely used as a monomer for polyesters and polyurethanes, it can be used as antifreeze, plasticizer, detergent, preservative as well as humectant. Among them, the most important application is a monomer for production of polypropylene terephthalate (PTT), a high quality polyester with the advantages of both nylon and terylene, having chemical resistance, light stability, elastic recovery, and dyeability. Nevertheless, the production of PTT is greatly limited by the supply of 1,3-PDO that is currently produced by an expensive and small-scale fermentation process. Therefore, it is highly desirable to seek new technology for 1,3-PDO production. Here, a new technology for 1,3-PDO production by catalytic hydrogenolysis of glycerol has been developed. By using a highly efficient and durable catalyst and fixed-bed reactor, this technology enables the easy continuous operation of the reaction process, simple and low cost of catalyst/product separation. Compared with the fermentation process, the catalytic hydrogenolysis process is more economical, especially for mass production (e.g., 100,000 ton/a). In addition, this technology provides an excellent method to upgrade the biodiesel byproduct glycerol that helps to increase the income of the biodiesel industry.

Technical Advantages

- Continuous fixed-bed operation, simple process, easy to scale up to 100,000 ton/a.
- The catalyst is highly selective to 1,3-PDO and durable for a long time.
- Compared to the fermentation process, the present technology has the advantage of lower glycerol consumption, lower cost for product separation and purification, and more competitive in the market.
- A typical green and sustainable technology by providing high-quality biomass-based polyesters, which is greatly encouraged and financially supported in many countries.



Figure1. Platform for catalyst research and development

Certification and IP

- A catalyst for preparing 1,3-propanediol by glycerol hydrogenolysis, authorized, ZL201210140284.5.
- A bimetallic catalyst for production of 1,3-propanediol from glycerol, authorized, ZL201410592546.0.
- A bimetallic catalyst in the glycerol hydrogenolysis process for preparing 1,3-propanediol, authorized, ZL201510882004.1.
- A catalyst containing multi-active components for production of 1,3-propanediol based on glycerol hydrogenolysis, authorized, ZL201510933866.2.
- A catalyst for preparation of 1,3-propanediol by hydrogenolysis of glycerol, authorized, ZL201611127797.7.
- Application of multi-active component catalyst to the preparation of 1,3-propanediol by hydrogenolysis of glycerol, authorized, ZL201810603609.6.

Potential Market

- The main product 1,3-PDO is applied as monomers for production of PTT polyester and estimated to have a market capacity of 100,000 ton/year. The side products include 1,2-PDO, n-propanol and isopropanol, and they are widely used as antifreeze, solvents and disinfectants.
- The raw material for producing 1,3-PDO here is glycerol, which is a byproduct in producing biodiesel and is now in large surplus supply.
- The technology can produce bio-PTT, and contribute greatly to the reduction of the carbon footprint.



Figure 2. Fixed-bed reaction system as well as product purification system

Technical Parameters

- Operation conditions: 50 wt% glycerol aqueous solution, GHSV=300~1000h⁻¹, LHSV=1-2h⁻¹, H₂ pressure 4~8MPa, reaction temperature 160-200°C.
- Single-pass conversion of glycerol ≥10%, single-pass selectivity of 1,3-PDO ≥50%. By products include 1,2-PDO, n-propanol and isopropanol.
- The catalyst life time ≥3000h, and after simple regeneration it can be as long as one year.

Cooperation Models

- ☒ Technology licensing



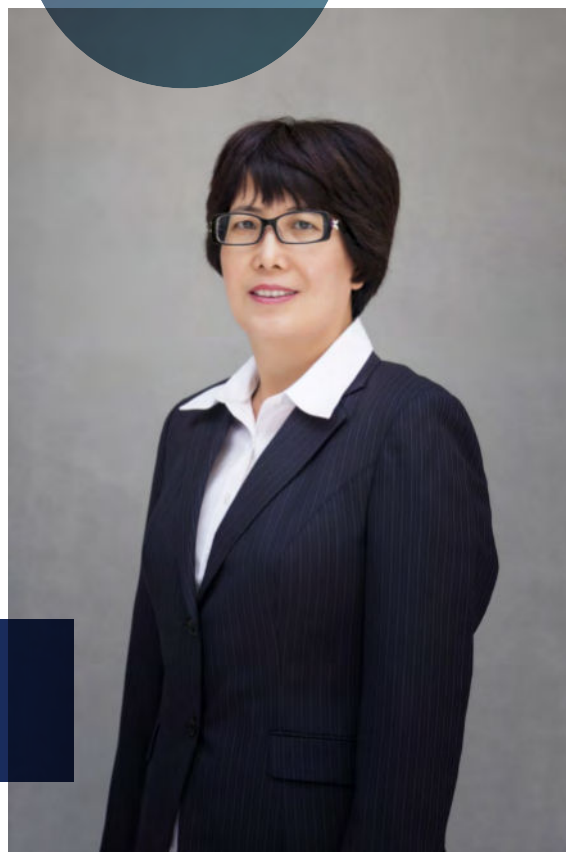
WANG Aiqin PhD, Professor

Prof. WANG's research interests include catalytic conversion of biomass, subnano- and single-atom catalysts, and green synthesis of value-added chemicals. She is the author or co-author of more than 300 peer-reviewed scientific publications, and serves as an editorial board member of Chinese Journal of Catalysis and an Advisory Board member for Sustainable Energy and Fuels.

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**Lead
Scientist**



Brief Introduction Technical Advantages

Ethanol, one of the most important green chemicals, can be used as a fuel additive, hydrogen carrier, chemical feedstock, and so on, and its production has triggered wide research interest in the fields of both science and technology. Currently ethanol is mainly produced by the fermentation of sugars and corns. However, limited production capacity of ethanol by the fermentation of biomass materials cannot meet large-scale demand for ethanol in various fields. The synthesis of ethanol by Dimethyl ether (DME) carbonylation to methyl acetate (MAc), followed by hydrogenation of MAc, is a potential way with the low materials of natural gas, coal, biomass and tail gas of steel plants. Through this green route for ethanol synthesis, we built the world's first coal to ethanol plant that has been in operation successfully since 2017. This is a major breakthrough across the world for the conversion of coal.

- The reaction system is anhydrous, and anhydrous ethanol can be obtained directly after separation.
- Since there is no/trace acetic acid, no special material is required and its capital cost is low.
- Low cost and high economic benefit due to mild reaction conditions.
- A single ethanol synthesis unit can reach the production level of one million tons.
- Abundant sources of raw materials, including coal, natural gas, biomass and steel plant tail gas.

Technical Parameters

- Reaction pressure is 5-8Mpa, the carbonylation reaction temperature is about 190-230°C, and the hydrogenation reaction temperature is around 200-230°C.
- The selectivity to methyl acetate is more than 99%, and that of ethanol is more than 98%.
- The stability of carbonylation catalyst and hydrogenation catalyst is more than 1 year.



Figure1: The 100,000 t/a methanol to ethanol project

Potential Market

- Natural gas, coal, biomass and steel plant tail gas can be used as raw materials for ethanol production.
- Methanol or dimethyl ether plants can be transformed into ethanol plants by this technology.

Cooperation Models

- ☒ Technology license



Figure2: Technical identification



Figure3: 500 000 t/a methanol to ethanol plant under construction

LIU Zhongmin PhD, Professor

Prof. LIU is the Director of DICP, CAS; Director of National Engineering Laboratory for Methanol to Olefins and National Energy Low-carbon Catalysis and Engineering R&D Center. He has been working on catalysis research, process development, and technology transfer in energy conversion and utilization, and made significant achievements. The world's first commercial units of MTO (Methanol to Olefins) and MTE (Methanol to Ethanol) technologies were developed under his leadership.

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Lead
Scientist



Brief Introduction

Energy storage is the basic equipment and key technology to support the construction of new clean energy-based power systems, to advance the green and low-carbon energy transformation, achieve carbon neutrality and guarantee national energy security. Vanadium flow battery (VFB) is known to be efficient electrochemical energy storage device for the conversion between chemical energy and electricity via oxidation and reduction reaction of vanadium ions with different valence state, due to their features of high safety, high efficiency and long cycle life. Here, we have made breakthroughs on the key technology of VFB, and implemented nearly 20 demonstration projects including the largest 10 MW/40 MWh vanadium flow battery system in China. Currently, we are working on the largest 200 MW/800 MWh VFB system in the world, where the first stage of 100 MW/400 MWh has almost finished installation. In the recent five years, about 200 inventions have been patented and 19 standards on flow batteries, including one international standard, have been formulated.

Technical Advantages

- Aqueous solutions are employed, with very high safety and no risk of fire or explosion.
- Independent design of power and capacity, power rating from kW-100 MWs, capacity rating from kWh-100 MWhs. The power can be scaled up by increasing the number of stacks, while the capacity can be scaled up by increasing the volume of externally stored electrolytes.
- Long cycle life (>15 years), high energy efficiency (system efficiency >75%).
- High performance, deep-discharge capability, fast response time, and low self-discharge ratio.
- Recyclable electrolyte, environment friendly.

Technical Parameters

- Stacks with power rate ranging from 5-40 kW, energy efficiency higher than 80%.
- Fabrication and mass production of key materials for vanadium flow battery, stack and system integration.



Figure1: 5 MW/10 MWh vanadium flow battery demonstration system



Figure2: The largest national 10 MW/40 MWh vanadium flow battery demonstration system

Potential Market

- Wide applications across the entire electricity domain including electricity generation, transmission and distribution, and user side.
- Energy management, peak-shaving in grid-connected, micro-grid and large-scale energy storage in renewable integration and in grid.
- Provide backup power in remote areas with limited grid connectivity or in off-grid applications.

Cooperation Models

- ☒ Technology licensing or transfer
- ☒ Technology development



Figure3: New generation 30 kW vanadium flow battery stack



Figure4: 100 MW vanadium flow battery plant



**Lead
Scientist**

LI Xianfeng PhD, Professor

Prof. LI is the Deputy Director of DICP, CAS; Head of Energy Storage Division. Prof. LI's research mainly focuses on electrochemical energy storage techniques including flow battery, lithium-based batteries, sodium-ion battery, lead-carbon battery, etc. He was awarded the laureate of the second prize of National Award for Technological Invention, Distinguished Young Scholar of National Science Foundation of China (NSFC), "National Youth Top-notch Talent".

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Brief Introduction

Higher alcohols (with 6 or more carbon atoms) are important chemical feedstock. The present technology to synthesize higher alcohols is through multi-step processes that first convert the synthesis gas (a mixture of CO and H₂) to hydrocarbons by the Fischer-Tropsch synthesis method, and separate it to get alkenes, then a hydroformylation-hydrogenation process is utilized to produce higher alcohols in the SASOL process. It is a complex multi-step process with a high-cost reaction path. The novel catalytic technology to direct-convert synthesis gas to higher alcohols and diesel is a one-step process, and the hydrocarbon and alcohols in the raw product can be easily separated via the conventional distillation-extraction method to produce C₆-C₉ alcohols (plasticizer alcohols), C₁₀-C₁₄ alcohols (detergent alcohols) and the single-carbon-number alcohols. This new technology is a promising process for the efficient synthesis of higher alcohols and other high value-added chemicals from syngas with a short process flow, low-energy cost, and good profit.

Cooperation Models

- ☒ Technology licensing or transfer

Technical Advantages

- Synthesis of higher alcohols is a new way of syngas conversion into high value-added chemicals, and a breakthrough in the transformation of the syngas chemical industry to a high value-added process.
- One-step synthesis of higher alcohols from syngas has the advantages of a simple process, low energy consumption and high economic efficiency.
- The process has nearly zero CO₂ emission and reduces the operating energy consumption.
- The slurry bed reactor has high efficiency of heat and mass transfer, high operation stability, large capacity per unit, low investment cost, and low marginal cost of production.

Technical Parameters

- Reaction temperature 210~250°C, reaction pressure 2.0~4.0 MPa, GHSV=2000-3000 h⁻¹.
- Alcohols in liquid product ≥60%, C₆+ higher alcohols in total alcohols ≥60%.
- Compared with SASOL process, our energy efficiency increased more than 15%.
- Annual operation rate ≥90 %, single unit scale ~500 kt/a.



Figure 1: The 100 kt/a industrial demonstration plant for higher alcohol synthesis from syngas

Certification and IP

- Activated carbon supported cobalt-based catalyst for directly converting of synthesis gas to mixed linear alpha-alcohols and paraffins, authorized, US7670985B2.
- Catalyst for adjusting the performance of higher alcohols synthesis from syngas and its preparation and application, authorized, ZL201510854580.5.

Potential Market

- Suitable for production of clean liquified fuel and high value-added chemicals from coal, natural gas, and biomass.
- Replacement and upgrading of SASOL for higher alcohol synthesis.
- Replacement and upgrading of the conventional high energy consumption, high emission, and low value syngas conversion process.

Figure 2: The slurry-bed reactor of industrial demonstration plant



**Lead
Scientists**

DING Yunjie PhD, Professor

Prof. DING is the group leader of Syngas Conversion and Fine Chemicals Research Centre in DICP/CAS. His research interests include syngas conversion and fine chemical catalysis, etc. He has received the Science and Technology Development Award of CAS, and National Labor Medal of China.

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Brief Introduction

Olefins hydroformylation is the conversion of olefins, hydrogen, and carbon monoxide to aldehydes, with further conversion into chemicals such as alcohols, acids, and esters, which are the primary raw materials for high value-added fine chemicals such as detergents, plasticizers, or surfactants. However, there are some problems with homogeneous hydroformylation, such as the difficulties in the separation between catalyst and product, leaching of precious metals and ligands, inefficient utilization of reaction heat, and massive use of solvents. On the other hand, our new technology adopts porous organic polymers with large specific surface area and hierarchical porous structure as a carrier and a ligand, loading to form an ultrahigh stability catalyst with the active single metal species (rhodium and cobalt ions) through multiple coordination bands. In August 2020, the industrial facility for producing n-propanol was successfully put into operation in Ningbo Zhejiang province, and the quality of propanal and n-propanol has reached the excellent grade of international standards.

Technical Advantages

- The utilization rate of precious metals is nearly 100%, and the leaching of precious metals and ligand is negligible.
- Almost no cost in separation of catalyst and product.
- The reaction system adopts a green solvent-free process, and the products have high purity.
- Large amount of low grade reaction heat is utilized efficiently in hydroformylation and hydrogenation reaction.

Cooperation Models

- ☒ Technology licensing or transfer



Figure1: 50 kt/a industrial facility for ethylene hydroformylation to produce propanal/n-propanol

Technical Parameters

- Hydroformylation reaction temperature 70-120°C, reaction pressure 1-3MPa, GHSV=2000-4000 h⁻¹, LHSV=1-2 h⁻¹.
- Hydroformylation total conversion >98%, one-pass conversion >30%, aldehyde selectivity >98%.
- Hydrogenation reaction temperature 100-140 °C, reaction pressure 1-2MPa, LHSV=1-3 h⁻¹, ratio of H₂ and aldehyde 50-150.
- Hydrogenation total conversion >99%, alcohol selectivity >98%.

Certification and IP

- A heterogeneous catalyst for hydroformylation of olefin and its application, authorized, ZL201310684768.0(2).
- Method for olefin hydroformylation reaction by heterogeneous catalyst, authorized, ZL201310675799.X.

Potential Market

- Suitable for low olefins (such as ethylene, propylene, refinery dry gas) and high olefins (such as octene, decene, cyclohexene) hydroformylation and hydrogenation reaction.
- Suitable for mixture of olefins hydroformylation and hydrogenation reaction.



**Lead
Scientist**

DING Yunjie PhD, Professor

Prof. DING is the group leader of Syngas Conversion and Fine Chemicals Research Centre in DICP/CAS. His research interests include syngas conversion and fine chemical catalysis, etc. He has received the Science and Technology Development Award of CAS, and National Labor Medal of China.

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Brief Introduction

Pesticide residues are the main factors affecting the quality and safety of agricultural products. At present, rapid-detecting devices for pesticide residues on the market are mainly based on the principle of enzyme inhibition, which is only sensible to highly toxic pesticides including organophosphorus and carbamates, but with little response to most of medium and low toxicity pesticides. According to the National Food Safety Standard of China (GB 2763-2021), more than 400 pesticide varieties need to be analyzed, and most of them are medium and low toxicity pesticides. Therefore, enzyme inhibition method can no longer meet the actual needs of food safety supervision. Other rapid detection methods such as enzyme-linked immune and colloidal gold nanoparticle methods, have been developed but generally suffer from numerous problems including single pesticide detection, relatively complicated operation and high cost, making them difficult to be applied widely. The new multiple pesticides rapid detection method systematically integrates various technologies such as photochemical colorimetry, advanced indicator immobilization, multi-layered filtering and enhancement, etc., and can be used for rapid detection of more than 70 kinds of commercialized low toxicity pesticides such as sulfur-containing organophosphorus, pyrethroids, dithiocarbamates, thiocarbamates and heavy-metal-containing pesticides in 1-5 minutes. In July 2018, ZhongKe (Dalian) Rapid Analysis Technology Co., Ltd. was jointly established by DICP/CAS and Jiangsu Feixiang Chemical Co., Ltd Through an intellectual property swap to industrialize this technology successfully.

Technical Parameters

- Limit of detection (LOD) is lower than 1 mg/kg (fruits & vegetables).
- Analysis time is less than 5 minutes.
- The test results are reliable, and the repeatability is about 98.5%.
- Light source: special LED with ultra-bright and ultra-narrow divergence angle, assures the accuracy and repeatability of the light-source wavelength.
- Low energy consumption, only 1 W.
- Portable design with the size of: 174*70*52 mm.

Technical Advantages

- Be able to detect more than 70 kinds of pesticides with simple operation in short time.
- Special pesticide residues rapid detectors for the assessment and digital readout guarantee a high accuracy result.
- With the functions of GPS positioning, remote data transfer and big data analysis, it can easily support informatization management.



Figure1: Rapid test strips and detectors based on multiple pesticides rapid detection technology

Certification and IP

- A sensor for detecting dithiocarbamates pesticides and its preparation and application, authorized, ZL201510943787.x.
- A sensor for organophosphorus pesticides containing sulfur, its development and application, authorized, ZL201610251290.6.
- A method for detecting pesticides containing heavy metals, authorized, ZL201610251522.8.
- A fast test strip for pyrethroid pesticides containing cyanogen, its preparation and application, authorized, ZL201610251288.9.

Cooperation Models

- ☒ Technology licensing or transfer
- ☒ Technology development

FENG Liang PhD, Professor

Prof. Feng is the Director of the Department of Instrumentation and Analytical Chemistry in DICP/CAS, and he has been selectively supported by “Dayu Zhang Outstanding Youth Fund (2017, DICP)” and “Fund for Distinguished Young Scholars (2018, Dalian)”. He has published more than 70 papers in Nature Chemistry, J. Am. Chem. Soc., Anal. Chem., Chem. Commun. etc., and has more than 110 patents in which 40 of them are authorized. During the past few years, he has been successively honored as “Talents of Liaoning province”, “Ten oversea outstanding youth of Liaoning province”, “Distinguished Young Scholars of Dalian” “Leading (bench) talent of Dalian city”, “Outstanding young scientific and technological personnel of Shenyang branch of CAS”.

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Potential Market

- Suitable for on-site pesticide residue screening by food safety inspection institutions at all levels.
- Suitable for self-inspection of pesticide residues on fruits and vegetables by enterprises or small business owners.
- Suitable for quick check of pesticide residues on fruits and vegetables in canteens, restaurants and ordinary families.

Lead Scientist



Brief Introduction

The Polytetrafluoroethylene (PTFE) hollow fiber membrane contactor technology refers to a new separation process that combines porous PTFE hollow fiber and traditional unit operations of chemical engineering. Interphase mass transfer can be realized when two phases are not separated by an interface. Compared to the traditional direct contact processes such as absorption tower, the membrane contactor has the advantages of compactness, small size, high efficiency, and low energy consumption. Moreover, it avoids shortcomings such as gas-liquid ratio limitation, flooding, and entrainment in nature. This technology has prospects for wide application in chemical separation, process intensification and environmental protection. So far, the pilot demonstrations or industrial applications of PTFE membrane contactor technology have been realized in some industrial processes such as decarbonization of offshore natural gas, biogas purification, treatment of ammonia-nitrogen wastewater, and membrane distillation for saline-water reclamation.

Technical Advantages

- PTFE hollow fiber membrane has outstanding hydrophobicity, chemical stability and antiwetting property that meet the technical requirements of membrane contactor for industrial application.
- The specific surface area for mass transfer is up to 2000m²/m³, which is one order of magnitude higher than the conventional devices such as absorber.
- Two phases in membrane contactor does not contact with each other directly, thus avoiding the shortcomings in gas-liquid ratio limitation, flooding, and entrainment.
- PTFE hollow fiber membrane contactor has compactness, small size, high efficiency, and low energy consumption.

Cooperation Models

- ✓ Product sales
- ✓ Technology licensing or transfer
- ✓ Technology development

Technical Parameters

- Outer diameter of PTFE hollow fiber membrane: <1.0 mm; average pore size: 0.1~0.4μm; porosity: >50%; static water angle: >105°; specific surface area: ~2000m²/m³.
- Application in decarbonization of offshore natural gas: the volume of equipment decreases by 30% compared to the conventional absorber, and CO₂ content in treated gas can be lower than 50 ppm.
- Application in treatment of ammonia-nitrogen wastewater: the ammonia-nitrogen concentration can be lower than 10 mg/L; there is no ammonia leakage and secondary pollution.
- Application in membrane distillation for saline-water reclamation: water flux of 3.0 L/m².h and salt rejection rate higher than 99.9%.

PTFE hollow fiber development → Membrane contactor process → System design and integration

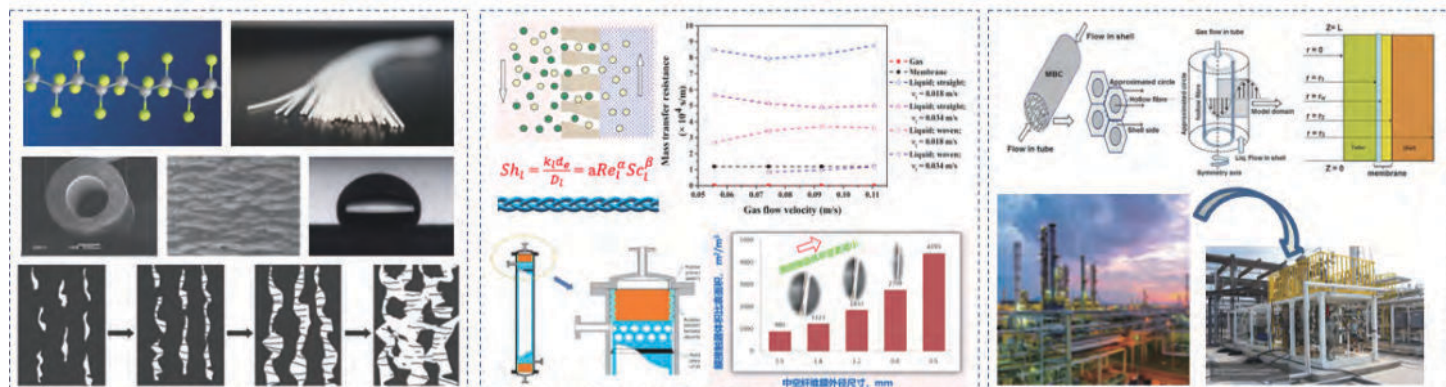


Figure 1: Development of PTFE hollow fiber membrane contactor technology



Figure 2: Pilot study of PTFE membrane contactor for decarbonization of natural gas (Malaysia)



Figure 3: PTFE membrane contactor for biogas purification

Potential Market

- Suitable for decarbonization and desulphurization of natural gas in offshore platform with limited operating space.
- Suitable for purification of distributed energy resource such as biogas to produce bio-natural gas.
- Replacement of traditional air stripping tower and absorber with high energy consumption and high pollution for the treatment of ammonia-nitrogen wastewater.
- Combined with solar energy and industrial waste heat for sea water desalination, saline-water reclamation, and solution concentration.

Certification and IP

No.	Patent Name	Application Number	Patent Type	Patent Status
1	Preparation of Polytetrafluoroethylene Hollow Fiber Membrane and Membrane and Membrane Contactor and Application Thereof	CN201611096701.5	Invention	Granted
2	Hollow Fiber Membrane Contactor and Application Thereof	CN201610895357.X	Invention	Granted
3	Preparation Method of Polytetrafluoroethylene Hollow Fiber Composite Membrane	CN201610396865.3	Invention	Granted
4	Preparation Method, Membrane, and Its Application of an Ultra-hydrophobic PTFE Microporous Membrane	CN201310438475.4	Invention	Granted
5	Preparation and Application of Polytetrafluoroethylene Hollow Fiber and Membrane	CN201210554647.X	Invention	Granted
6	Process and System for Treating Natural Gas Feedstock	PCT/CN2013/000840	Invention	Granted in China, Canada, Australia, Malaysia, and Indonesia
7	System and Method for Solvent Regeneration	PCT/CN2018/084174	Invention	Published
8	Improved Gas Exchange System and Method	PCT/CN2019/099721	Invention	Published



Figure 4: PTFE membrane contactor for the treatment of ammonia-nitrogen wastewater



**Lead
Scientist**

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Prof. Kang's research interests include new membrane materials and separation development. In recent years, he and his team have successfully developed PTFE hollow fiber membrane contactor technology for chemical separation and process intensification. He won the first prize of the Dalian Municipal Award for Technological Invention, and the first prize of the Membrane Industry Association of China.

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