



Institute on Membrane Technology
ITM-CNR - Italy



Report on
**Membrane Research, Membrane Production and
Membrane Application in China**



Report prepared in the framework of the **Section on Membrane Engineering** of the European Federation of Chemical Engineering (EFCE).

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Introduction

In this report we are presenting the state of the art in the **People's Republic of China (PRC)** updating a previous report printed in 2007.

It is interesting to note the significant growth of membrane activities in the Country particularly in the area of desalination and municipal water purification. This interest is documented also by the industrial realization in Reverse Osmosis (RO) units, Ultrafiltration (UF) and Membrane BioReactor (MBR). Also at fundamental research level, various new Institutes are focalizing their attention in the development of membrane research projects. Interesting cases are at the Tsinghua University, Harbin Institute of Technology, Dalian Institute of Chemical Physics State Key Laboratory of Catalysis, Chongqing University, Ocean University of China, Jiangsu Polytechnic University (JPU) in Changzhou, etc.

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1. A survey of the development of membrane science and technology in China

1.1 History of membrane development

The research and development on membrane science and technology in China started from ion exchange membranes in 1958 [1].

Exploring research on reverse osmosis (RO) membranes was set about in 1965. A national joint research project on sea water desalination began in 1967. This played an important role in training research team and laid a good foundation for the progress of membrane science and technology.

A magnificent period for membrane research and development started at the beginning of the seventies. The membranes and related modules for electrodialysis (ED), RO, ultrafiltration (UF) and microfiltration (MF) had mostly been developed in this period. At the same time, a study on liquid membrane (LM) was also started.

A great success was achieved in 1980s concerning the development of new membrane processes. Seawater and brackish water desalination, pure and ultrapure water production, separation, purification and concentration of various liquids by membrane technology were applied on medium and large scale. At the same time, gas separation (GS) membranes development started. The membrane processes for oxygen enrichment and separation of N_2/H_2 were studied on pilot scale. Good results were obtained in the concerning the synthesis of perfluorosulfonic and carboxylic ion exchange membrane. Studies on pervaporation (PV), membrane distillation (MD), membrane extraction (MEx), membrane phase separation, inorganic membranes (IM) and membrane reactors (MR) were also started.

In 1990s, composite membranes for RO and NF were manufactured on pilot scale. GS for N_2/H_2 were tested in fertilizer factories. Preparation and preliminary application of inorganic membranes and new types of ion exchange membranes, sea water desalination by RO and dehydration by pervaporation were realized. Water reuse by membrane processes and application of membrane technology in bioengineering processes have also started.

At present, new technologies and new processing techniques on membrane production are constantly being discovered and invented. Membrane application is being expanded to more and more fields, of which application of membrane technology in water treatment market mainly covers three aspects: seawater desalination, recycling wastewater and purifying water. China's total investment in seawater desalination through 2010 is expected to reach CNY13.6 billion to CNY18 billion, of which 30% to 40% will go to the production of membrane and membrane module so as to make China's total volume of seawater desalination reach 800,000~1,000,000 t/d in 2010 from current 40,000 tons per day. Profit of membrane separation industry is about 100-200%. About 90% membrane separation engineering companies are involved in manufacturing equipment for the production of industrial pure water, high pure water and civilian pure water and the competition in the industry is quite fierce. About 30 membrane separation engineering companies are engaged in the separation and purification of industrial liquid and the treatment of industrial waste

water. According to the statistics, only a few companies use membrane technology to manufacture equipment for the treatment of electroplating wastewater, the recovery of precious metals and reuse of water, which are newly developed fields in the application of membrane technology. Technology of designing and producing industrial and civilian pure water equipment is more mature and easier to be mastered relatively.

1.2 Brief introduction of different membrane processes

1.2.1 Ion Exchange Membranes and ED

Research on ion exchange membranes began in 1958 with the development of the first membrane realised in PVA [1]. Many types of membranes have been studied and developed since, but the most widely used are heterogeneous membranes of polystyrene-divinylbenzene. The research work on homogeneous ion exchange membranes began, instead, in 1970 [2]. In the 1990s, China produced cation and anion exchange membranes on a large scale. These membranes have excellent electro-chemical properties and a good mechanical strength. At the moment, they are used in the electrodeionization process, in separation and purification of glycine from its reaction mixture, in preparation of iminodiacetic acid, citric acid and tartaric acid by electrodialysis, in treatment of pulp-making black liquor, in electro-metallurgical processes and as diaphragm in fuel cells. Properties of some heterogeneous and homogeneous ion exchange membranes are reported in Table 1.

Table 1. Properties of some heterogeneous and homogeneous ion exchange membrane [1].

Type	Thickness (mm)	Water content (%)	IEC meq./g	Resistance ($\Omega\text{-cm}^2$)	Permsel-ectivity	Blast strength (Mpa)	
Heterogeneous *	3361 (cation-exchange)	0.4-0.5	35-50	≥ 2.0	≤ 12	≥ 92	> 0.3
	3362 (anion-exchange)	0.4-0.5	35-45	≥ 1.8	≤ 13	≥ 90	> 0.1
Homogeneous **	DD-120 (anion-exchange)	0.25	49	1.96	2.0	98	> 0.8
	DF-120 (cation-exchange)	0.22	44	1.57	1.4	92	> 0.7
	DF120 (anion-exchange)	0.25	49	1.96	2.0	98	> 0.8

*the material is polystyrene-divinylbenzene **the material is cross-linked PPO

Currently, the annual output of IEC (mainly heterogeneous membrane) is about 500,000 m², which is the head of the world. And, the R&D of homogeneous membrane also obtained importantly new progress. For an example, Tianwei Membrane Co. Ltd. has the annual throughput of homogeneous membrane as much as 50,000 m². The present information on some chinese commercial available ion exchange membranes is tabulated in Table 2.

Table 2. Main properties of some chinese commercially available homogeneous ion exchange membranes

Membrane	Type	Thickness (mm)	IEC(mol/g (meq/g))	Area resistance (Ωcm^2)
Tianwei Membrane Co. Ltd (Homogeneous)				
TWEDG	AEM	0.16–0.21	1.6–1.9	3–5
TWDDG	AEM for DD	0.18–0.23	1.9–2.1	<3
TWAPB	Proton blocker	0.16–0.21	1.4–1.6	5–8
TWANS	Nitrate selective AEM	0.17–0.20	1.2–1.4	6–10
TWAHP	High protein flux	0.20–0.21	1.2–1.4	<2
TWAEDI	AEM for EDI	0.18–0.21	1.6–1.8	6–8
TWCED	CEM	0.16–0.18	1.4–1.6	2–4
TWCDD	CEM for DD	0.16–0.18	1.6–2.0	2–4
TWCEDI	CEM for EDI	0.16–0.18	1.2–1.4	5–8
Xiangfeng water treatment equipment Co. Ltd. (Homogeneous)				
PE-203	AEM	0.1–0.5	1.5–2.1	4–10
PE-001	CEM	0.1–0.5	1.8–2.2	3–6
Shanghai chemical plant. (Heterogeneous)				
3362	AEM	0.4-0.5	≥ 1.8	≤ 13
3361	CEM	0.4-0.5	≥ 2.0	≤ 12
Zhejiang Qianqiu Group Co. Ltd (Heterogeneous)				
	AEM	0.38-0.46	1.8	13
	CEM	0.38-0.46	2.0	12
	AEM for EDI	0.55-0.65	1.8	20
	CEM for EDI	0.55-0.65	2.0	15

Apart from traditional ion exchange membrane-based processes, numerous electro dialysis (ED)-based technology have been studied. The applied theories on ED including concentration polarization, water splitting, electrode behaviour and hydrodynamics in compartments were mainly conducted in the 1970s [1]. There are many configurations of ED/EDR units with the largest size of the membrane and spacer area of 1600×800 mm. More than 1000 ED units have been produced by nearly 40 factories. New applications of ED process in the biomedical, food and energy resources industries have been identified. Some of them have gained increasing attention as efficient techniques in clean production and wastewater treatment.

Clear production: For traditional methods of producing organic acid, the related traditional techniques, including precipitation and acidification, extraction, crystallization, distillation, ion-exchange, and adsorption, are unavoidable. Obviously, it is difficult to meet the requirements of green chemistry. Ge Dao-cai et.al proposed a new process for producing d - tararic acid from its

sodium salt solution by electrodialysis. The process has the advantages of simple operation and high yield. The purity of the product, d-tararic acid, is over 99.5%, the recovery ratio is more than 95%, and the content of sulfate anion in the product is less than 0.01%. The power consumption is about 2000 kWh/t. Compared with the traditional methods, the new method has obvious priority. Xu Tong-wen et al. successfully produced gluconic acid from its sodium salt solution by bipolar membrane electrodialysis with three-compartment configuration. The recovery ratio of its sodium salt is as much as 98.6%. The current efficiency is 71.5%. The energy consumption is 1.03 kWh/kg. According to primary evaluation, the cost is only 2.81 ¥/kg acid.

Wastewater treatment: The treatment and recycle of NH_4NO_3 waste water was carried out by electrodialysis in Shanxi Xinghua Chemistry Co. Ltd.. The content of NH_4NO_3 in the wastewater is 16340 mg/L. After electrodialysis treatment, the NH_4NO_3 was concentrated to 15%, and the salt content of the recycled water is 380 mg/L. The output of concentrated NH_4NO_3 is 3.2 t/h, and the 26.8 t/h water was let.

In addition, studies on bipolar membranes and EDI processes have been also carried out. In 2006, EDI prototypes and equipments with the feed of products of two-stage RO were operated successfully for pure water production in Huangdao Power Plant, which is 3000 m³/h, the largest unit capacity in China.

1.2.2 RO, NF, UF and MF

The study on RO was started in 1965. The research on UF and MF is from the beginning and in the middle of 1970s respectively. NF membrane technology was firstly studied around 1989, initially as a kind of loose reverse osmosis membrane [3].

Flat and tubular cellulose acetate (CA) asymmetric RO membranes, including CA, CA-CTA & CAB, studied first in 1960s. Studies on aromatic polyamide membrane materials, including PSA, and related hollow fiber RO membranes, and CTA hollow fiber RO membranes were started at the beginning of 1970s, and it has been industrialized and promoted into application in the 1980s.. Studies on RO composite membranes formed by interfacial polycondensation and in-situ polymerization, and dynamically formed membranes as well as SPS membrane began in the middle of 1970s. An exploration of composite reverse osmosis was undertaken and put into pilot-scale application with great success. Table 3 shows performance of polysulfone amide (PSA) RO membranes developed in 1970s-1980s. Table 4 shows performance of composite positively-charged membranes developed in 1980s for UF of cathode electrophoresis paints.

Table 3. Performance of polysulfone amide (PSA) RO membranes [1].

Type	Performance		Test condition			
	Flux(1/m ² .h)	Rejection(%)	Operating pressure (MPa)	Feed concentration (mg/l)	Temperature (°C)	pH
PSA-1	43	98.2	5.0	300(NaCl)	25	7.0
PSA-2	17.6	99.3	4.0	2700(Cd ²⁺)	25	12.0

Table 4. Performance of composite positively-charged UF membranes [1].

Type	Performance		Test condition		
	Flux(1/m ² .h)	Rejection(%)	Operating pressure (kPa)	Paint concentration (%)	Temperature (°C)
HN-01	25	99	150	20	25

The PSA RO membrane could be used for concentrating plating waste water containing Cr⁶⁺, because PSA membrane has good resistance to oxidation of Cr⁶⁺. In further study, the performance of the PSA membrane was influenced by metallic complex ion in plating solution. Especially the flux of the membrane was decreased with the increased ration of CN/Cd²⁺ in plating solution.

In China, research on NF was carried out in the late 80's. In 1990s, under the National financial aid, the NF technology was systematically studied and developed, including the materials for the preparation of NF membranes, the manufacture process and the machine of NF membrane and element, and the application of NF technology. However, applications of NF are mainly in the experimental stage only. The commercial materials of NF membrane include: cellulose acetate (CA), cellulose triacetate (CTA), polyamide (PA), sulfonated polysulfone (SPS), sulfonated polyether sulfone (SPES), Piperazine polyamide (PPA), and polyvinyl alcohol (PVA) and so on. Domestic studies on the NF materials are focused on phenolphthalein polyethersulfone sulfonated side chain, sulfonated polyethersulfone, sulfonated polysulfone, cellulose acetate, amines and epoxides by the positively charged synthetic polymers and acrylic acid copolymer and so on. The methods for the preparation of NF membrane include: phase inversion method, solution dip-coating method, interfacial polymerization method and thermal induced phase inversion method.

Domestic studies on UF started in the 1970s. In 1977-1978, composite UF membrane was fabricated successfully using polysulfone as membrane material. In the late of 1980s, there are more than 20 units and more than 30 factories engaged in the study of UF membrane and production, achieving an annual production value of several million RMB. The materials of UF mainly include cellulose acetate, polysulfone, polyacrylonitrile, PVDF, PVC, polyether sulfone, polysulfone amide, which were put into production and application. Plate, tube, hollow fiber, roll and cassette are main forms of UF membrane modules. Currently, UF has been widely used in seawater desalination, ultra-pure water preparation, biological, chemical, pharmaceutical, medical, food and environmental protection areas, these areas become an important means of separation. For example, recycling or re-use of oil Wastewater is essential UF in the removal oil of the related research has made some progress, and gradually move from the laboratory stage of practical application. In April 2005, using PVDF UF membrane tube of small treatment plants, oil fields in Taixing, a joint station pilot, test results showed that the data in each group meet or exceed the treatment plant design parameters. Improved the water treatment field Hing Joint Station of Taixing oil field formally put into operation in December 26th 2005, the design capacity of 350 m³/d.

Spiral wound and hollow fiber modules have been widely used in RO/NF and UF processes, respectively. The pleated filter cartridges and flat sheets are the main usable forms in MF. There are more than 100 factories manufacturing varieties of RO, UF and MF membranes, modules and plants. Most of them have been also serving related engineering.

Performance of composite RO membranes and modules, typical performance of NF membranes and typical performance of NF elements are shown in Table 5, Table 6 and Table 7.

Table 5. Performance of composite RO membranes and modules

Membranes& modules	Performance		Test condition
	Flux/output	Rejection(%)	
membrane	>40 (l/m ² .h))	>98	1.6MPa <2000mg/l
Modules Φ100mm	>6.8m ³ /d	97--98	1.6MPa <2000mg/l

Table 6. The typical performance of NF membranes [3].

Material	Solute Rejection [%]					Test Conditions
	NaCl	MgSO ₄	Na ₂ SO ₄	MgCl ₂	Sucrose	
PA	60	>98	>98	40	>98	Feed: 2000 mg/l Pressure: 1.0 MPa Temperature: 25°C
SPES	50	40	>90	5	>40	
CA	50	>90	-	-	-	
CTA	55	>95	>95	-	-	

Table 7. Typical Performance of NF Elements

Material	Element	Performance		
		Flux (l/h)	NaCl Rejection(%)	MgSO ₄ Rejection(%)
CA	SW100-1000	200	≤50	≥98
CTA	HF130-1300	700	≤50	≥98
PA	SW100-1000	480	≤30	≥95

Testing Conditions: 2000mg/l, 1.0MPa, 25°C

Table 8. Main properties of RO elements

Items		HOR21-8040	HOR21-4040	HOR-2012
Properties	Average rejection, %	99.2	99.2	97.5
	Lowest rejection, %	99.0	99.0	96.0
	Average flux, GPD(m ³ /d)	9000 (34.1)	2200 (8.3)	50 (0.19)
	Membrane area, ft ² (m ²)	365 (33.9)	85 (7.9)	5.0 (0.46)
Testing conditions	Operation pressure	225psi(1.55Mpa)	225psi(1.55Mpa)	60psi(0.41Mpa)
	Operation temperature	25°C	25°C	25°C
	Feed concentration (NaCl)	2000ppm	2000ppm	250ppm
	Feed pH	7.5	7.5	7.5
	Recovery of each element, %	15	15	15
Critical condition	Highest operation pressure	600psi (4.14Mpa)	600psi (4.14Mpa)	300psi (2.07Mpa)
	Highest operation temperature	45°C	45°C	45°C
	Highest feed SDI15	5	5	5
	Feed free chlorine	< 0.5ppm	< 0.5ppm	< 0.5ppm
	Feed pH	3~10	3~10	3~10
	Chemical cleaning pH	2~12	2~12	2~12
	Pressure drop of each element	15psi (0.1Mpa)	15psi (0.1Mpa)	10psi (0.07Mpa)

RO is mainly used in seawater and brackish water desalination, pure and ultrapure water production, separation and concentration of some liquids in food, beverage and chemical industries. A few sea water reverse osmosis desalination plants with the capacities of 500-2500m³/d have been operated in different region. UF is mainly used in concentration of enzymes, proteins and other high molecular weight substances, and recovery of electrophoresis paints, as well as purification of water (seawater, surface water, municipal sewage, trade waste, et al), beverages and other liquids. MF is found its uses in pharmaceutical industry and others for rejecting micro-particles and bacteria from related liquids or gases. NF is used in water softening, purification and concentration of dye solution etc.

More than 2×10⁵t/a of enzymes have produced in China. Popularization of the UF technique has had a big promotion for enzyme production. The schematic flow-chart is shown in Figure 1.

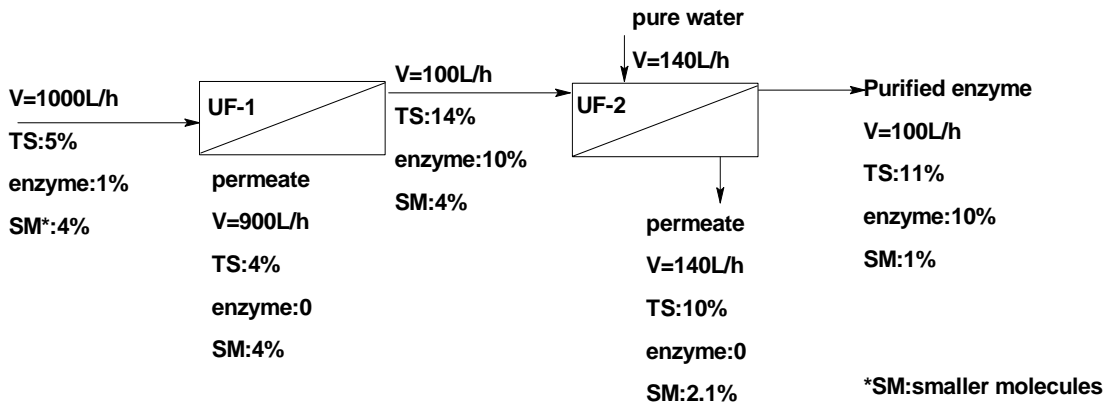


Figure 1. Schematic flow-chart of enzyme production using UF system

Figure 2 shows the progress of BWRO (Brackish Water Reverse Osmosis) membrane performance in the past three decades [4]. In 1970's, much effort for researching a new high performance membrane material had been devoted, and consequently crosslinked polyamides were developed in 1980's. The crosslinked aromatic polyamide composite membrane developed in 1987 had 4 or 5 times larger water permeability and five times less salt passage than that of the CA membrane. After 1987, the permeability of BWRO membranes had been rapidly improved due to extensive researches for crosslinked aromatic polyamide composite membrane. Typical performances of the BWRO membrane elements of each decade are shown in Table 9. The super ultra low pressure membrane element which can be used at 0.5 MPa has already been developed [5]. This membrane element can be operated with 1/3 of operating pressure of the low pressure membrane.

Figure 2. Progress of BWRO membrane performance.

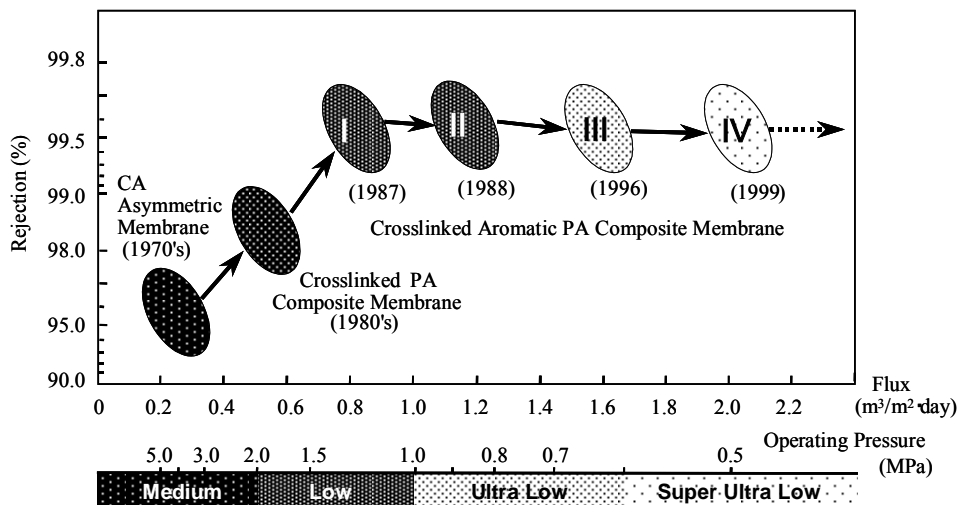
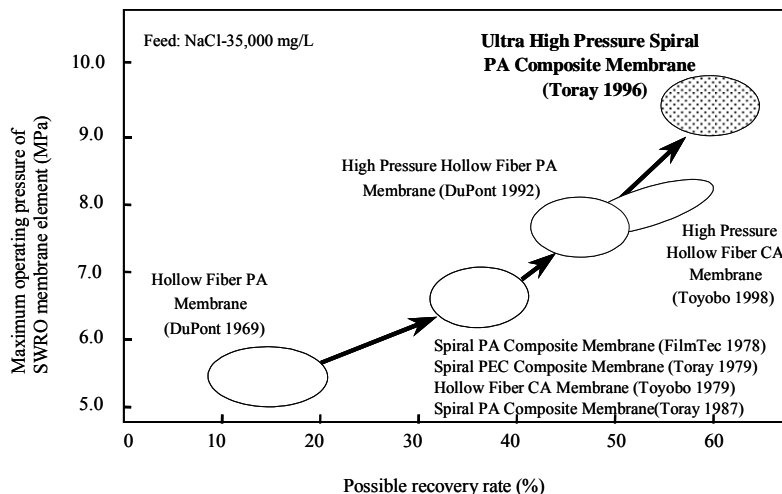


Table 9. Typical performance of BWRO membrane element released from Toray.

Coverage	Low Pressure		Ultra Low Pressure III	Super Ultra Low Pressure IV
	I	II		
Product name (Launched year)	SU-720 (1987)	SU-720L (1988)	SUL-G20 (1996)	SUL-H20 (1999)
Performance				
Salt Rejection (%)	99.4	99.0	99.4	99.4
Water Permeability (m ³ /d)	26.0	22.0	26.0	26.0
Testing condition				
Operating Pressure (MPa)	1.5	1.0	0.75	0.5
Temperature (°C)	25	25	25	25
Feed Conc. (mg/l)	1,500	1,500	1,500	1,500
Brine Flow Rate (l/min)	80	80	80	80

In Figure 3 is shown the progress of SWRO (Seawater Reverse Osmosis) membranes ([4], [6], [7], [8]). It is important for cost reduction to increase recovery rate on SW desalination system. High recovery rate operation contributes to the cost reduction of pre-treatment process due to the reduction of feed water amount and the equipment scale. However, the recovery rate of SWRO desalination system had been usually limited to approximately 40% conversion of the feed water when the salt concentration was 3.5%, since most of commercially available SWRO membrane did not allow high pressure operation more than 7.0 MPa. Therefore an high pressure resistant membrane had been researched in order to overcome the increasing osmotic pressure. For example, Toray has developed the ultra high pressure resistant membrane which can be operated with maximum operating pressure of 9.0 MPa or more. The SWRO membrane element using this membrane enabled 60% of high recovery rate operation.

Figure 3. Performance trends of SWRO membrane element.



Recently Toray [4] and Hydranautics [9] have focused attention on membranes for the removal of boron. As a matter of fact, seawater is composed primarily of sodium (Na^+) and chloride (Cl^-), but also contains other monovalent and divalent ions and approximately 5 mg/l boron (B) which, due to its size and charge, is not well rejected by RO membranes.

Boron has increasingly become a concern in recent years due to its adverse effects on agriculture at concentrations as low as 1 mg/l. Additionally, because of the human health effects of boron are under investigation and not yet fully understood (until now, in the lab tests, it has been noticed that boron has toxic effects, which impairs animal growth and causes nerve damage), the World Health Organization (WHO) recommends a maximum boron concentration in the drinking water to be below 0.5 mg/l as a provisional guideline value, while the Japanese Water Quality Standard for Drinking Water of 1998 reinforces regulation and tolerates a boron concentration of 1.0 mg/l.

For the reasons described above, currently the number of seawater desalination plants equipped with boron removal facilities is growing.

The Hydranautics proposes in China the following RO membranes for the first-pass: SWC3, SWC3+, SWC4 or SWC4+. The boron rejection of these membranes are 89%, 91%, 92% and 93%, respectively, higher than that of the conventional element. However, these values still do not produce desalted water with boron concentration that satisfy the WHO drinking water quality guidelines. Therefore the product water from the first-stage seawater desalination RO membrane is treated to raise its pH to the level of 9.5 and then sent to a second-stage RO membrane for boron removal. Finally, the product water from the second-stage membrane is treated by adding acid to adjusted the pH until the value recommended by WHO. Membranes to be used in the second-stage are, for example, ES20 or ES20B by Hydranautics.

Toray proposes in China to use single stage RO operations, with TM820A membranes. The boron rejection in those membrane elements is 94-96%, values that allow to meet only Japanese Water Quality Standard. But in severe condition, for the WHO guideline grade or the Middle East seawater treatment (with the highest boron concentration), rejections between 97 - 99% are needed. The ultra-low pressure RO membrane ES20B for boron removal has been adopted by a seawater desalination plant in Fukuoka (50,000 m³/d) and is now on operation as from May 2005.

In order to reduce water costs further, there is a need for an RO membrane which can satisfy water quality standards but with a single-stage treatment.

1.2.3 Emulsion Liquid Membranes

Since emulsion liquid membrane (ELM) was found by Li in the 1960s [10], ELM separation process has attracted researches' attention with a wide various applications, such as metal recovery process and purification of organic and inorganic compound from industrial waste water or dilute solution in chemical industry. In other fields such as immobilization of enzymes as well as prolongation of drug release, applications of ELM have been novel research subjects.

Since that time an important progress has been made both in the theoretical and practical aspects [1]. Theoretical studies include stability, swelling and breakdown mechanism of the emulsion, synthesis of new effective surfactants, new emulsion liquid membrane systems, effect of frequency and wave pattern on breakdown emulsion by pulse electric field, supported emulsion liquid membranes and electrostatic pseudo liquid membranes. Many experiences have been performed on some practical pilot systems. Removal of phenols, treatment of plating waste containing Cr or Zn, extraction and concentration of rare-earth elements, gold enrichment and recovery of cyanide are typical examples.

1.2.4 Dialysis and Artificial Kidney

Dialysis is now mainly used for recovery of acids [1] and Nephrology in China. Recovery of acids from waste acids by dialysis is a more advanced and economic way than other processes, such as neutralization, sedimentation ion exchange and evaporation at low pressure. As an example, Baoji Nonferrous Metal Works has used membrane DF-120 for regenerating waste acids (HNO₃+HF) from titanium processing. Total recovery of 85-90% can be reached from 5N waste acids. Exchange membranes (S-203,DF-120) have been developed specialty for dialysis, shown in Table 10. The membrane S-203 is based on quaternary ammonium poly phenylene oxide. The process of dialysis is very simple, as shown in Figure 4.

Table 10. Two homogeneous ion-exchange membranes used in Dialysis

Type	Thickness (mm)	Water content (%)	IEC (meg/g)	Resistance ($\Omega\text{-cm}^2$)	Permselectivity (%)	Blast strength (MPa)	stability
S-203	0.10-0.30	20-35	1.1-1.5	< 8.0	>90	≥ 0.6	Resistant to acid
DF-120*	0.25	30-36.1	1.96	1.4-2.7	98	>0.8	ditto
Cation*	-----	30-36.1	1.82	1.4-2.7	98	0.7-0.9	

* produced by Shandong Tianwei membrane technology company Ltd.

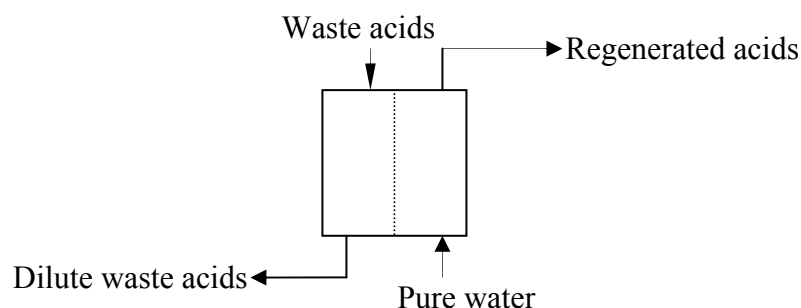


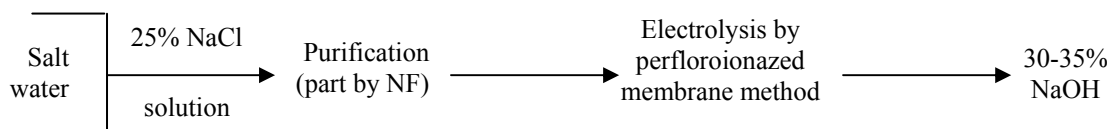
Figure 4. Flowchart of waster acid recovery by dialysis

Efforts to develop a complete registration system for dialysis and transplantation in China began in 1998. Now, both hemodialysis and peritoneal dialysis are widely used in China, with approximately a 40-50% survival rate in three years. Hollow fibers studied and developed for artificial kidney are until now imported in China from Germany and Japan. Good results have been obtained in recent years in the development of polyethersulfone (PES) hollow fibers for artificial kidney on a pilot scale. And, relative new hemodialysis membrane manufactured by a blend of PES and polyvinylpyrrolidone (PVP) was evaluated in vitro and in vivo, whose results indicated that PES/PVP hollow fiber membrane had a potential widely use for hemodialysis. Other related is blood filter and concentraters.

1.2.5 Membranes in Chlor-Alkali Industry

From 1980 to 1990, the synthesis routes and technological process for preparing perfluorosulfonic and perfluorocarboxylic ion exchange resins were determined and tested on pilot scales [1]. Resins with high IEC and good strength were also prepared. The optimal technological parameters for the membrane formation from the two resins and their mixture by extrusion have been obtained. The manufacture of composite perfluorosulfonic and carboxylic membranes by vacuum technique in the batch scale were also brought to success. At the same time, the transformation by hydrolysis and surface modification for large size of the membranes were completed.

Applications of these membranes in Chlor-Alkali industry is being expanded after 1997 and replacement of asbestos diaphragm and mercury cathode methods by perfluoroionized membrane method is the inevitable trend. The output of NaOH in China is about 2.0×10^7 t/a, in which more than 1/3 is produced by perfluoroionized membrane method. The basic technology is as follows:



Usually cell voltage is 3.3V, current density is 3-4 kA/m², energy consumption is about 2200-2500kWh/t NaOH. Other typical project include 40,000t/a ionic membrane caustic soda project in Fujian in 2004 and ionic membrane chlor-alkali of 100,000t/a project started in 2007 in Binzhou, Shandong.

Dongyue Group Ltd. is the main company of Dongyue International Fluorine & silicon Material Industry Park, which is the first fluorinated material base in China. After 20 years effort, the company had established a hi-tech fluorine & silicon material product line in new environmental protection, new material and new energy fields. In 2005, the production line of fluorinated material ion membrane with the capacity of 50000m²/a was installed. In the environmental protection field, the company has established 2×10^5 t/a environmental friendly refrigerants product line and implemented worldwide largest CDM Project.

1.2.6 Gas Separation Membranes

The study on gas separation membranes began in the end of 1970s. A great breakthrough has been made in N₂/H₂ separation and O₂ enrichment, and related demonstration applications have got good results also in the last 15 years.

Much work has been done on the research of membrane materials, such as the choose, synthesis and development of new materials, molecular design of the membrane materials, and related evaluation of their performance. The modified silicone rubber (PDMS), special polyimides, poly-4-methyl-1-pentene (PMP), brominated PPO, and poly-1-trimethylsilyl propyne (PTMSP) are examples of new materials.

PS hollow fiber resistant to high pressure, epoxy resin tube plate resistant to heat and pressure, and integral formation of composite layer in whole module have been developed for N₂/H₂ separation in recent years. The production of the hollow fiber module is in pilot scale, and the products have been used for H₂ recovery in fertilizer and refinery factories.

Reinforced PS supporting membranes, coating composite layer on the surface of the supporting membranes, technique for making spiral wound module and technological design for O₂ enrichment have also completed in recent years. The modules have being used for health protection and combustion supporting in glassworks.

The further improvement of the processes above, the research for N₂ enrichment and separating other gases, new membrane materials, hybrid processes and process optimization has also being carried out.

Table 11 shows the performance of different gas separation modules.

Table 11. Performance of different gas separation membrane modules [1].

	membrane	module size	Q (Nm ³ /h)	α
Hollow fiber	PS Hollow fiber coated with silicone rubber	ϕ 50mm*3000mm	~20	$\alpha_{H_2/N_2} > 25$
		ϕ 100mm*3000mm	~100 ($\Delta P < 10MP_a$)	
		ϕ 200mm*3000mm	~400	
Spiral wound	PS Hollow fiber coated with silicone rubber	ϕ 100mm*1000mm	~4 (> -560mmHg)	$\alpha_{O_2/N_2} = 2$
		ϕ 200mm*1000mm	~15	

The influence of greenhouse effect is becoming more and more obvious. CO₂ is the main part of greenhouse gases and its separation has attracted attentions around the world. Some researches in China were attempted to add some units that own great CO₂ solubility to polyimide and got very good results. These novel polyimide materials (5 series and more than 10 kinds) all showed much greater CO₂ permeability with higher separation factors over other gases such as N₂, CH₄ and even H₂. With these materials we prepared asymmetric and double layer composite hollow fiber membranes for CO₂ separation. Moreover, a successful project for separation of CO₂ from low quality natural gases was carried out. This project is the first CO₂ separation membrane equipment

in China (with CO₂ concentration higher than 80% and treatment scale 40,000 m³/d) and has won many attentions. What is more, it showed very satisfactory economic benefit and had run successfully for more than one year.

1.2.7 Inorganic Membranes

Inorganic membrane is a porous fine ceramic filter which is sintered from Alumina, Titania or Zirconia under ultra high temperature. In China, the methods for manufacture of inorganic membranes have been studied in 1980s, and mature preparation technology includes sol-gel process, anode-oxidation, coating and sintering, dynamically formed, and deposition etc.

Due to the distinct advantage of excellent acid/base resistance and mechanical and abrasive resistance, high solvent and thermal stability, and easy to be cleaned and sanitized with backflush, ceramic membrane products have been successfully applied in different applications ranging from pharmaceutical industry to food & beverage industry and waste water treatment. The other inorganic membranes are mainly used in high temperature reaction, such as hydrogenation and dehydrogenation.

JIANGSU JIUWU HITECH CO.,LTD founded in 1997 is a professional manufacturer for ceramic tubular membrane in China. So far the total annual output of ceramic membranes area is over 6000 m², with active layer functions separation ranging from MF, UF and even NF (from 10µm down to 1KD). Table 12 and Table 13 show the property parameters of main ceramic membrane products and the performance of different inorganic membranes, respectively.

Table 12. Property parameters of ceramic membrane products

Pore size & MWCO	0.8-1.4 µm	0.2-0.5 µm	0.1-0.2 µm	20-50nm	20-50KDa	5-20KDa	1KDa	450Da
Outside diameter/mm	10	25	25	25	30	30	40	40
Channel diameter/mm	7.0	6.0	3.3	2.0	6.0	4.0	6.0	3.6
Quantity of channel	1	9	19	37	7	19	19	37
Total length/mm	1016	1178	1178	1300	1016	1016	1000	1000
Membrane area/m ²	0.02	0.2	0.23	0.30	0.158	0.24	0.358	0.418

Table 13. Performance of different inorganic membranes [1].

Pore size (µm)	supporting	membrane	Flux(L/m ² .h)	Withstand Pressure(MP _a)	pH
0.05	Al ₂ O ₃	Al ₂ O ₃ , ZrO ₂ , TiO ₂	300~400	>1	0~14
0.2			800~900	>1	0~14
0.8			1100~1300	>1	0~14

1.2.8 Pervaporation

The study on pervaporation started at the beginning of 1980s. The membranes mainly used were cross linked PVA membranes and PVA and chitosan alloy membranes. The other membranes, such as polyimide membranes and ion-exchange membranes, were also studied and tested. Synthesis of new membrane materials, small module design, manufactures and evaluation of the module performance and process optimisation are other studies under investigation.

In Table 14 the performance of different PV membranes is reported. A comparison of membrane performance between MPV0401 and GFT1000 is shown in Table 15.

Table 14. Performance of different PV membranes [1].

Type	Performance		Teat condition		
	Flux (g/m ² .h)	a	Feed concentration	Vacuum(mmHg)	Temperature(°C)
PV-1	120	1350	95%(wt) ethanol	2	70
PV-2	235	542	95%(wt) ethanol	2	70

Table 15. Comparison of membrane performance between MPV0401 and GFT1000

Type	Feed temperature (°C)	Ethanol concentration in feed (wt %)	Flux (g/m ² h)	Separation factor α	Membrane life-span (a)
MPV0401	80	95.4	420	500	1-2
GFT1000	80	95.0	225	361	1-2

1.2.9 New Membrane Processes

These processes include vapour permeation, membrane distillation, membrane extraction, membrane reactor, membrane phase separation, membrane electrode, affinity membrane, control release, etc. Most of them now are still in their research and development stages.

Relatively low temperature requirement for membrane distillation is its major advantage. The PTFE, PP and PVDF strong hydrophobic membranes are used in the process which is still performed on laboratory scale. The concentration polarization, temperature polarization and membrane infiltration are the main obstacles for the process and also the main research aspects. The process is tested in laboratory for saline concentration, juice concentration, recovery of NH₃ from the waste of fertilizer factories, Br₂ recovery from saline water, etc. The osmotic distillation and osmotic membrane distillation are also studied in laboratory.

In recent years many studies have been performed in the field of membrane reactors (MRs) since one or more reaction products can be separated from reaction system, so the reaction rate and conversion rate can be raised significantly. Many works have been done in membrane selection, immobilization of catalysts, transferring process and pilot experiment. MR is mainly tested in

industrial chemistry and biochemistry, such as improvement and production of penicillin, fermentation and hydrogenation or dehydrogenation, etc. MR has its promising future.

Study on affinity membranes was carried out at the beginning of 1990s. After basic research on materials, ligands and coupling etc, some affinity membranes were prepared and used in separation of endotoxin and purification of γ -interferon.

Other membranes and processes, such as membrane extraction, membrane phase-separation, membrane electrode, control release, LB membranes and biological membranes, etc., have been also studied in their different stages. Some progress on molecular-recognition microcapsule membrane for controlled-release has been made in recent years. For example, a glucose-sensitive microcapsule with a porous membrane and with linear-grafted polyacrylic acid (PAAC) chains and covalently bound glucose oxidase (GOD) enzymes in the membrane pores acting as functional gates was successfully prepared and got excellent results.

2. Application of Membrane Technology in Food Industry

The application of membrane technology in food industry is growing gradually in both international and domestic market since 1960s. Advanced characteristics such as high separation precision, better selectivity, operation at room temperature, no high temperature or chemical damage, high automation, easy operation, economic energy, reduced cost, comprehensive utilization of resource and reduced pollution are the main advantages of the membrane technology in this field of application.

One of the Academic centers which studies and develops several applications of membrane technology in food field is the College of Food Science & Nutritional Engineering, CAU in Beijing, China.

MF, UF, RO and NF are today frequently used in the food industry. The main applications include: removal of microorganism from food, purification or concentration of water, fruit juice, vegetable juice, whey, vinegar, soy, wine and beer; concentration or separation-purification of proteins, polypeptides, fats, sugars, mucus, starch, scour and lysozyme; purification of oil, decolouration of oil and wastewater treatment.

2.1 Brief introduction on applications of membrane technology in different food industries

2.1.1 Application of membrane technology in drinking water, juice and beverage industry

The production of pure water by Electrodialysis, Ion Exchange, UF, RO is very common now.

The disinfection, clarification and concentration of fruit juices by membrane technology are also mature and reliable. Comparing with conventional technology, advantages are in terms of: reduction of clarification lines, simplification of clarification processes, increasing of clarified juice volume, possibility to operate at room temperature preserving the juice freshness, aroma and nutritional

value, improvement of the quality of the final product through the removal of extraneous substances.

Shanxi Haisheng Fresh Juice Co., Ltd adopts the advanced juice production facilities such as UF and processes more than 10 kinds of hard fruits, its annual production of concentrated juice reaches more than 5000 tons [11].

Habei Chengde set up a production line for the integrated utilization of hawthorn by UF and RO. Its annual production capacity reaches 1500 tons and 100 tons of fruit colloid. The separation ratio of fruit colloid, sugar, acid and pigment in hawthorn fruit by UF reaches 99.0%, 98.1%, 97.0% and 98.0%, respectively.

Wahaha pure water is a typical example of using membrane technology to produce potable water. Dalian Light Industry College adopts the UF clarification technology to produce seaweed and apple fruit and its annual capacity is 3000 tons. Shandong Xinyang Food Industry adopts UF to clarify pear vinegar. Its production is about of 2000 tons of vinegar per year.

The application of UF and RO technology in the production of instant tea in China is very efficient in stopping cold and preserving faint scent of tea.

China is the 3rd country in the world for the production of fruit (45 million of tons/year) and the 1st country for the apple production (15 million tons/year). Besides, particular hawthorn, pear, bink and passionflower, have function of health-protection and added value. In 2004, the production of soft drink in China was 26.8407 million tons. If membrane technology is broadly applied in beverage industry (especially fruit and vegetable juice), counting from the above economical progresses, numerous benefits will be created. If good membrane facilities made in China can replace foreign processing production, facility investment will be saved and membrane facility enterprise will find a great development opportunity.

2.1.2 Application of membrane technology in separation and purification of oligosaccharides, in production of propagating oil and low polysaccharide

The waste water from food processing contains various valuable components such as proteins, saccharides and salts, and it is very important to recover them for the full utilizations of valuable resources. UF membranes retain proteins and permit saccharides and salts passing by. RO membranes reject all components apart from water. However, saccharides and some multivalent salts are rejected by NF membrane and most monovalent salts go through the membrane to a certain extent. NF is an effective method for coupling separation of salts and saccharides solutions. For example, NF45 membrane from Dow Chemical Corporation [12], has shown good performance for concentrating saccharides and removing sodium chloride from the mixed solutions of saccharides and sodium chloride because of the large difference of observed rejections to them by the membrane.

Membrane technology has been applied in dairy processing since 1970s in several countries. UF and RO have been adopted to concentrate raw milk and skim milk, remove salts and small molecule

minerals, separate protein and peptide and reclaim protein and lactose from cheese whey wastewater. Advantages are in terms of lower change of protein's nature, improvement of product quality and energy saving.

Concentration of egg white and egg by RO in the processing of egg white powder and egg powder and distillation of fish protein by membrane technology using fish processing wastewater are efficient ways to improve yield, reduce energy consumption and integrated utilization of resources.

Soybean producers in US, such as ADM, have commonly adopted UF to produce purified soybean protein [11]. In China, Beijing Food Institute, Chinese Food Fermentation Industry Institute and Xi'an Oil Research Center have all investigated on the production of soybean separate protein by membrane technology. Compared with the conventional acid-isolation, the soybean is not treated by chemical treatment, thus the denaturalization is lightened and quality of product is improved. UF can improve the separate protein ratio by 10%, nitrogen dissolved ratio by 5% and protein ratio 5%. It can also separates Soybean Oligopeptide, Soybean Isoflavones, low polysaccharide and saponin, which are all healthy-protection active material. At the mean time, it can also reclaim wastewater, simplify production, reduce cost and improve economical benefits. However, in industrial processes problems such as membrane fouling need to be solved. In foreign countries studies on the use of UF to eliminate toxic Apigenin-7-O-glucoside, production of concentrated rapeseed protein and separation of rapeseed protein have been reported.

Heilongjiang Tianju Group adopted membrane facilities made in China to reclaim low polysaccharide from wastewater of isolate soya protein whey. Advantages are in terms of lower pollution and reuse of resources. Hagoke Food Co., Ltd also introduced advanced membrane separation facility to produce soybean low polysaccharide.

Jiangnan University adopted UF technology to separate active material, from milk. Xinjiang Tianrun Dairy Industry Co adopted from Denmark a 30-tons infant food production line that uses UF to produce foremilk powder. Beijing Zhongmu Lvyuan Biotech Co. and Dongbei Agriculture University chose hollow fiber UF Membrane Bioreactor to produce low lactose products by hydrolyzation. Zhejiang Changxin Aige Biotech Products Co. adopted UF technology to produce vitellus immunoglobulin; the annual production reaches 5 tons. Shandong Wandefu Plant Protein Co. used membrane technology to separate low molecular weight polysaccharide from whey. Shandong Jinluo Soybean Factory reclaim protein by distillation, using RO to concentrate low molecular weight polysaccharide. At present the production capacity of Isolate Soya Protein reaches nearly 70,000 tons in China. The development of membrane technology and its application in soya protein separation and in all kinds of dairy products will play very important role in the development of these two industries.

Shandong Longli Co. and Shandong Baolingbao Co. also adopted membrane technology to produce low molecular weight polysaccharide.

2.1.3 Application of membrane technology in beer and wine production

Membrane technology is used in beer production to carry out filtration, concentration, production of rotbeer and reclaim of waste liquid; to realize disinfection and clarification, reduce content of alcohol, produce wine; the application of UF in wine production will add aroma to wine, makes the taste to be soft; in the production of other fruit wine, yellow wine, wine, membrane technology can remove deposit such as pectin, ferment metabolize material, realize clarification. All these applications will improve the quality, simplify techniques and reduce costs [11].

At present in the wine production technique, the application of membrane technology to filtrate wine is very common. As a matter of fact, producing wine requires, besides elaborate vinification, a filtration step to remove unwanted substances from wine, so called clarification. Until 20 years ago all wine filtration was done with kieselguhr [13].

The conventional kieselguhr filtration typically is a form of dead-end filtration. The filter contains a layer of kieselguhr, that serves as filter medium. The wine is pushed through the filter medium and the substances are trapped in and on the layer of kieselguhr. After a while the kieselguhr is saturated, the layer is removed for disposal and is replaced by a fresh layer of kieselguhr. This conventional method of filtration however produces waste, consisting of the spent kieselguhr and the retained substances from the wine. This waste has to be disposed off at a cost. Another not less important negative feature is the loss of wine, which reduces the potential revenues of the winemaker.

The filtration systems with diatomite or plank have already replaced the traditional filtration systems with cotton in Chinese wine production in last years [14]. However, some impurity such as some black or white dot, wools remained in wine after filtration with diatomite because that the older techniques in the pre-treatment were behind schedule, cardboard interspace was not uniform and the fiber was not firm. Another, if the operation is not appropriate, diatomite layer would break and shed off, the fiber in the plank will come into the wine with the increasing of alcohol in wine which causes that much suspensions and turbidity appeared in wine and the diatomite completely lose the percolation function. Therefore diatomite and plank filtration systems are selected for the pre-filtration in most of wine production, while membrane techniques are introduced in the second or end filtration gradually.

Therefore, the technical key step is how to choose an adequate filtration system.

Based on the actual usage experience of many years [14], the wine that are filtered with membrane of 0.45 μm pore diameter could attain the quantity request, which makes wine pure, transparent and with luster feel. But these require that:

- the percolation machine pores are uniform;
- there is more than one type of membrane category for the different choice;
- the selected membrane possesses an automatic cleaning function;
- the filtration cost is lower.

Diatomite, sand, cardboard and cotton as filtration systems couldn't attained the above requests.

In the mid eighties of last century X-Flow developed hydrophilic microfiltration membranes for the clarification of wine with the potential of providing a good alternative for conventional filtration [13]. Compared with this technique, membrane filtration offered less wine loss, no solid waste to dispose off and a continuous process. Other advantages were developed during a long program in cooperation with a major grape press manufacturer from France sponsored by the European Community. The membrane properties were adjusted in accordance with the demands of no loss in colour, nose and taste. This program has formed the basis of the current technology of cross flow microfiltration for wine clarification, applicable to white wine, red wine, sparkling wine, cider and most.

These type of membranes are capillaries with an internal diameter of 1.5 mm. They consist of PES/PVP and are permanently hydrophilic. Filtration occurs from the inside to the outside of the capillaries. Filtration takes place in cross flow modules type R-100 of 1 m length with 9.3 m² membrane area. The shell as well as the inserts of the module are made of stainless steel, which makes the modules suitable for filtration under relatively higher pressures both on the filtration side and the permeate side. This prevents the release of dissolved gases and as such enables filtration of sparkling wines.

The European development program revealed that a maximum pore size of 0.2 micrometer and an average pore size of 0.1 micrometer provide the optimum for colour, nose and taste. The membranes have a high temperature and chemical resistance, which makes them ideal for sterilisation with steam. Contrary to other capillary membranes in food and beverage industry, they show excellent mechanical strength.

The hydrophilic character appears crucial not only for the filtration properties, but also for its extremely low fouling tendency. This reduces the number of cleaning cycles considerably compared to other membrane materials.

More than other 200 sets of French membrane facilities have been introduced [11]. For example, Beijing Shunxing Wine Co, Ltd introduced membrane technology to filtrate wine in 2000 changing the conventional filtration of wine. Using this technology together with the former advanced vacuum ballonet mill, the enterprise took great market and developed fast. Great companies of beer production such as Yanjing Beer Group and Guangzhou Zhujiang Beer Group introduced advanced low temperature membrane filtration beer production line to produce draft beer with high-quality and long-shelf time. They made the “fresher, purer, more nutritious” draft beer popular and created new products. Yanjing draft beer introduced the membrane filtration facility from US Bohr Company.

Hangzhou Wine Company adopted UF technology to produce plum wine. Jilin Agriculture University adopted UF technology to clarify sweet maize wine.

China Great Wall Wine Co., Ltd. utilizes micro pore membrane of ZP from 1993 [14]. Now the company has six membrane filtration systems and the production is 210 thousand ton. ZP membrane system has different advantages as following:

- bearing acid, alkali, heat, microbe pollution and high pressure;
- high separation efficiency, simple craft, low cost and conventional maintenance;
- low failure rate and long life-span.

All these bring pollution solving and huge economic performance at low cost.

In 2004 the production of beer in China reached 27,576,800 tons. For strong wine, wine and yellow wine the production reached 2,743,800 tons, more than 500,000 tons and more than 1 million tons, respectively [11].

2.1.4 Application of membrane technology in condiment production

The application of membrane technology in condiment production, such as muddy removing, decolouration, desalting, filtration of vinegar, removing of bacteria, barm and impurity, bacteria separation, concentration and reclaim of glutamic acid from wastewater, will promote different advantages in terms of products recycling, simplification of techniques, improvement of product quality and transparency, prolonged shelf-time.

Foshan Tianhai Sediment Food Co, Ltd cooperates together with research center of Chinese Academy of Science in the production of clarified soy in large scale by UF. Its top-grade products are all realized by UF and the annual capacity is 50,000 tons. After UF, the soy is enriched of valuable components such as amino acid, deoxidize sugar, while the bacteria content is greatly reduced. The quality and performance exceeds the same kind in foreign countries. This product is well sold in more than 60 countries in Europe, America and Asia [11].

Beijing Hetiankuan Food Co, Ltd employs China-made membrane technology for removing bacteria and decolouration. Its product, no-colour soy, is exported in Japan.

At present in the spot check of sediment's quality, unqualified products still exist. However, various kinds of sediments are daily necessary material in Chinese diet, such as vinegar. So the quality of product is very important. It is hoped that sediment enterprises introduce advanced technology to improve product quality.

2.1.5 Application of membrane technology in oil industry

Membrane technology is applied mainly for mixed oil concentration, preliminary concentration of mixed oil by PSU (concentration increases from 25% to 45%), evaporation and stripping to remove solvent. This will save mass stream and reduce solvent by more than 40%.

The combination of UF and physical refinery to refine oil will save 25%-35% stream and 60% electricity, refine loss reduce 60%. The equipment investment will be also reduced [11].

At the same time the application of membrane technology in wastewater treatment, reclaim of waste gas (solvent), hydrogenation reaction catalyser, production of nitrogen will produce a series of advantages.

2.1.6 Application of membrane technology in sugar industry and functional components

In sugar production industry membrane technology can replace diatomite to filtrate, to make dextrose from amylase, and also clarify and filtrate sugar cane. It plays an important role for improving the quality of products.

Beijing Industry and Commercial University and Jiangnan University use UF to separate and concentrate aloe amylase. Yunnan Yuanjiang Wanlv Bio-tech Group set up a membrane concentration production line able to treat 10,000 tons of aloe in 2002. Beijing Chemical University and Dalian Institute of Chinese Academy of Science adopted membrane technology to produce chitosan. National Ocean Bureau Hangzhou Water Treatment Center uses membrane technology to reclaim manna from kelp water, thus reducing pollution. Harbin Medicine University separates valuable components from celery which are included in Qin Weikang capsules. Jilin Changbaishan separates Potassium Alginate by UF separation technology. Dalian Yaweite Biotech Engineering Co., Ltd developed food additives by NF and immobilized enzymes. Beijing Food Institute employs UF and RO to separate, extract and concentrate submerged-fermentation morchella [11].

2.1.7 Application of membrane technology in gluten production

MF, UF and RO technology can all be applied in gluten production. The clarification technique after decomposition can be realized by MF to replace diatomite. The permeate can be concentrated by UF, while RO system is used in reclaim of waste and water recycle. Beijing Food Institute concentrates Xanthan Gum by UF removing most part of proteic components and pigments [11].

2.1.8 Further applications of membrane technology

The application of membrane technology to concentrate and refine citric acid and enzyme preparation will improve the purity of enzyme from 20% to 90%. The usage of membrane technology is also very efficient in extract valuable material from ferment wastewater.

In the process of extraction and refining of natural pigment, reclaim of aroma components and treatment and reclaim of food industry wastewater, membrane technology is also very useful.

Among enterprises that utilize membrane technology, in the last decade a great development there has been in the fields of seawater and brackish water desalination, sewage and wastewater treatment and reuse.

3. Current situation, development and prospect of seawater desalination technology in China

3.1 Introduction

Water is the indispensable and irreplaceable natural resource that the mankind depended on for existence and production, the key element for all societies. Fresh water is needed in agriculture, as drinking water, or as process water in various industries; further, both the health and the quality environment in which we are living depend largely from water availability and from its quality.

In spite of the relative abundance of fresh water on the Earth, more than 75% of this amount, consisting of polar ice and seawater, is not actually exploitable. Besides, a conspicuous portion of the remaining quarter is constituted by water from underground stratum not yet intensively employed. The sources today used for hydraulic supplying represent therefore just the 1% of the total amount of water. As regard to the emerged lands, the hydro-geologic balance is on the credit side: although 110,000 billions of m³ of water reach the ground by precipitation, only 70,000 billions of m³ come back to atmosphere by evaporation. Unfortunately, this assets of water is heavily wasted in floods, marshes, rivers flowing through uninhabited regions etc...

Some relevant organizations of the United Nations point out “*water will become the most serious resource problem in the world*”, “*the problem of lack of water will restrict the economic and social development of next century and may cause the conflict across boundaries seriously*”, “*supply water inadequately will become a profound social crisis, the next crisis after the oil crisis is crisis of water worldwide*” [15]. The problem of lack of water is an actual global issue.

In China, in spite of the total volume of water resource is 2,812.4 billion cubic meters (occupying the 6th place in the world), nevertheless the pro-capita water resource volume is only ¼ of that of the world average, so much so that it is classified as one of the 13 poorest water shortage countries in the world. In more than 300 cities, water shortage has already become a serious problem, especially in the northern coastal area and in several islands (like Tianjin, Beijing, Hebei, Shandong, Henan, Shaanxi, Liaoning, Ningxia, etc). The coastal area represents the 15% of the whole country land. The coastline is more than 18,000 kilometres, the islands are more than 6500, population accounts for more than 40% of the whole country and it is also the most developed economical area of China. Water shortage has already become the bottleneck on development of social progress and economy. For a long time water has been considered an inexhaustible good. With the economy development and living standards improvement, the demand for water is raised, both in quantity and in quality. Nevertheless, the shortage of water resource, the inequality between the geographic distribution of water sources and the resident population, the over-limit exploitation, the waste and the pollution, all these increase the initial gap between supply and demand of water resource. Water resource lack has already influenced the development of coastal social economy. So, for the sustainable development of the country, is imperative to solve the problem of water scarcity.

Where the availability of water cannot be increased by using conventional sources, crucial appears the ability to provision fresh water utilizing the major water source: the sea. Seawater desalination processes represent a reliable remedy to water shortage and their application have completely changed the way people live their lives and where they choose to live. The change is most apparent in some large arid regions of the Earth. The desalination water output is about 47.5 million cubic meters per day in the whole world, solving the water supply problems of more than 100 million people (about 1/40 of the population in the world).

Throughout the research and development of more than 40 years, China has made considerable progress in distillation technology and reverse osmosis technology on seawater desalination. Seawater desalination output in China is about 270,000 m³ per day. It becomes an important measure to solve the industry and drinking water supply problem of a great deal of islands, coastal area and west region [15].

Seawater desalination has already been classified as one of priority developing technology in the “National Marine Economic Development Planning Outline” and “National Seawater Utilize Sub-plan”. To intensify the research and development of this technology and reach the international most advanced level, thus it can solve not only domestic coastal area desalination demand, but also participate in the international and enormous desalinization market competition, is an objective of the country.

Seawater desalination technology involves such fields as new material, chemical industry, environment and information, etc.; its development will drive the progress of these fields and then of the whole economy. The fast development of seawater desalination industry in China, can put this country in a favourable position for the future competition.

3.2 Technology of seawater desalination and current situation in China

Both distillation and membrane processes are already in use for desalination in China, with multistage flash (MSF) having received attention since the 1970s and seawater reverse osmosis (SWRO) being studied since 1965.

With the respect of distilling, the research and development on ship use distilling device of small-scale was the major focus in the 1960s, and the pilot-scale research on the MSF of the freshwater of hundred ton level between 1970s and 1980 has acquired some design parameter and experience; and from 1980s to 1990s, the pressure distilling device (atmospheric pressure and negative pressure) of 30 m³/d scale and put into trial use. The first laboratory installation of MSF was developed and operated in Tianjin city in 1981; its capacity is 72 m³/d. The first industrial MSF process was introduced by ES Co. in 1989 for supplying 2300 m³/d fresh water to Tianjin city, based on the introduced technology, and an MSF device, with fresh water yield of 1200 m³/d, was designed and used in 1997. An MSF process for producing 3000 m³/d fresh water was developed by Hebei Electric Power Equipment Factory in 1998 [1]. The process includes 3 evaporator sectors, which

have 27 flash vessel stages and one hot driving sector with 3 flash vessels; a brine water circulating system and spool structure are used.

In June 2004, a low-temperature multi-effect distillation (LT-MED) plant, the first independently designed by China, was installed at Huangdao Electric Power Plant in Qingdao city. The system with 9 effects can produce 3000 m³/d. The electricity power consumption of the plant is 1.6 kWh/m³ of water. Recently, Tsinghua University [3] developed a dual-tower stacked vertical evaporation tube LT-MED unit, which is an experimental test system designed to have an upper brine temperature of 120°C, a seawater mass flow of 3300 kg/h and a fresh water yield of about 180 kg/h. The system includes a steam generator, an evaporator, a pre-heater, a final condenser, and a seawater tank, coupled with a natural circulation nuclear heating reactor. A LT-MED device of a scale of 2×10000 m³/d is now being brought in and used for the supply of the electric power plant to the boilers. And it is said that the energy consumption of water with the introduced technology is at around 6-7kWh/m³. In April 2009, a 6-effects LT-MED unit was built and operated in Huanghua Cangdong Power Plant, with unit capacity of 12500 m³/d.

The LT-MED, on the level of the use of low geothermal energy, if it is combined with the power generation and on the condition that the output water is with low salt content, is competitive to some extent.

In 1967, the reverse osmosis out-of-phase ion exchange membrane was put into production, which provides conditions for the promotion and application of the reverse osmosis technology. Ever since the 1970s, a succession of manufactures and magnifying experiments of pilot-scale on various homogeneous phase ion exchange membrane, researches on electrode dynamics and the preparation of the titanium coating with ruthenium was electrode of new type, the development of the large size (800×1600mm) electrodialysis clapboard, the research on the ED hydraulics parameter, the design and development of the large scale ED membrane, the technology and the development of frequent exchange of the EDR, and the standardization of the equipment have been carried out, and abundant experience in engineering design and operation achieved, which all contributed to the development to the advanced level of the world. The ED seawater desalination plant of 200m³/d, which was set up at the Xisha Islands met the demand of the military and civil use with an energy consumption of 18kWh per m³ freshwater. By far, the annual output of the domestic ion exchange membrane is stabilized at 4.0×10⁵m², which accounts for one third of the ion exchange membrane for desalination over the world.

China has been studying reverse osmosis (RO) as an important goal since 1965. During a collective study conference on SWRO in 1966, an RO system with cellulose acetate membrane was demonstrated in Chaolian Island, the first RO system for seawater desalination. In 1997, a 500m³/d seawater RO desalination demonstration plant was constructed at Shengshan Island, Zhoushan. In 1999, a 1000 m³/d seawater RO desalination plant was set up at Da Changshan Island with a freshwater consumption of 5.5 kWh/ m³. At the end of 2000, two seawater RO demonstration plants of 1000 m³/d have been built up respectively at the Long island of Shandong and Shengsi of Zhejiang province. Later on, the Huaneng Electric Power Plant of Weihai and Dalian have

established 2000m³/d seawater RO desalination plant respectively, and then, the Rongcheng of Shandong and Dalian Petrochemical have built up 5000m³/d seawater RO desalination plant. From 1997 up till now (2008), over 40 SWRO desalination plants have been established with a freshwater consumption of 4kWh/m³ and a total capacity of 199,300 m³/d.

Seawater desalination has been primarily used in power, municipal feed, chemical engineering, steel industry and so on. For example, power plant with self-contained complete seawater desalination system is the main application form in the coastal area. According to statistics in 2007, 9 seawater desalination plants had been established by power plants, which capacity is up to 90,600 m³/d in total, accounting for 68% of total capacity of seawater desalination, and around 10,000m³/d per set in average. Among them, the seawater desalination projects for matching power plants with larger capacity include: Huaneng Yuhuan Power Plant, 30,000t/d; Huanghua Power, 100,000t/d; Huangdao Power 26,000 t/d; Yingkou Power Second, 50,000t/d, et al. Except for power industry, 22 seawater desalination plants which are applied into other industries enterprises have produced fresh water of 155,700 m³/d which accounted for 56% of total amount, and just 7,077m³/d per set. Take chemical industrial enterprises for example, Dalian Petrochemical Industry and Qingdao Soda Ash Industry have based mainly on reverse osmosis desalination technique which is generally small in scale but has great application prospects.

According to the industrial tracking and survey results by Desalination Association of China in 2008, 56 seawater desalination plants were established in China till December in 2008, and the total capacity is up to 276,100 m³/d, shown in Table 16. SWRO have been built with a capacity of 199,300 m³/d, in the first place; MED have been built with a capacity of 70,000 m³/d, in the second place. Among the seawater desalination plants, 47, 6, 1, 1 and 1 of them were adopted SWRO, MED, MSF, MVC (Mechanical vapor compression), and ED (Electrodialysis), respectively. The differences in number and capacity of plants are resulted from equipment scale. According to statistics, the average capacity of MED is 8375 m³/d, while the average capacity of SWRO is only 3747 m³/d.

Currently, 45 seawater desalination plants are under normal operation, which account for 80.4% of the total number of seawater desalination plants which have been built up, The corresponding capacity is up to 219,300 m³/d, which accounts for 79.4% of total water production and has increased by 35% compared with the last year. Water production of about 288,000 m³/d will increase by 9 seawater desalination plants being installed, which are mainly located in Tianjin, Shandong, Zhejiang, Liaoning and Hebei.

Table 16. Statistics of seawater desalination plants in China

Category	Projects in operation		Projects in progress		Projects in plan to build	
	Plants number (sets)	total capacity (10 ⁴ m ³ /d)	Plants number (sets)	total capacity (10 ⁴ m ³ /d)	Plants number (sets)	total capacity (10 ⁴ m ³ /d)
number	56	27.61	9	28.8	25	140

From the view of the production capacity growth by seawater desalination, the construction of desalination projects had suddenly accelerated since 2005 in China. About 10 desalination projects had completed each year, and the total amount of desalinated water had increased annually by more than 30%. Table 17 shows the growth of desalination capacity in China from 1990-2008.

Table 17. The growth of desalination capacity in China over years

time	~1990	1991~2000	2001	2002	2003	2004	2005	2006	2007	2008
water production (m ³ /d)	6400	6850	5500	1250	11660	5770	17280	80804	71620	72000

3.3 Toray – China BlueStar to Establish Water Treatment Joint Venture in China (to newly construct RO membrane production facilities) (source: <http://www.toray.com/news/eco/nr081125.html>)

On August 31st, 2009, Toray and China National BlueStar (Group) Co., Ltd. have announced that the companies established a water treatment joint venture, Toray BlueStar Membrane Co., Ltd., (temporary name; hereinafter referred to as “TBMC”) in Beijing on July 17, 2009.

The new company has a capital of 35 million U.S. dollars and 180 workers and engages in production, sales and import and export of water treatment membrane products. TBMC is planning to invest approximately 500 million yuan in construction of facilities for production of reverse osmosis membrane and assembly of membrane elements. Operations of the facilities are expected to commence in April 2010 in a phased manner. At the new production facility, the new company will introduce high-speed polyamide composite membrane manufacturing equipment and automatic winders for elements based on Toray's state-of-the-art technology. With this facility, it has been estimated that the reverse osmosis membrane element production annual capacity of the Toray Group will increase by 1.5 times in 2010 compared with the current level of the capacity including the Ehime Plant and Toray Membrane U.S.A. Inc. which are already operating.

3.4 Energy consumption and cost of seawater desalination

At present, 45 seawater desalination plants are under normal operation in China. Judged by the volume of production, the plants are mainly used for supplement of fresh water in industrial enterprises, and a small number of them supply the resident in some area and island lack of surface water sources with drinking water. Table 18 is a list of the operation cost and the investment of some typical installations.

Table 18. Investment and operation costs of part of seawater desalination projects in China

Categories	Huangdao Power plant in Shandong	Huaneng Power plant in Weihai	Huaneng Power plant in Dalian	Caofeidian Capital Steel Corporation	Yuhuan Power plant in Zhejiang	Wangtan Power plant in Datang	municipal use in Shengsi
Scale(m ³ /d)	3000	2500	2000	25000	34560	10800	4000
Technology	LT-MED	SWRO	SWRO	LT-MED	SWRO	SWRO	SWRO
Completion time	2004	2001	2001	August, 2008	March, 2006	February, 2005	2005
Application	boiler water (salt content<20ppm)	boiler water (single stage RO, drinking water standard)	boiler water (double stage RO, salt content<10ppm)	boiler water and recycle system supplement	boiler water (double stage RO)	boiler water (double stage RO)	municipal feed water
Total investment of projects (10 ⁴ RMB)	2400	1980	1910	25000	20000	8000	2880
Operation cost (RMB/m ³)	4.73	5.17	5.74	6.7	6.18	3.64	3.79
Investment of per ton of water (RMB/m ³ ·d)	8000	7920	9500	10000	5787	7407	7200(including water intake projects)
Corporation	Qingdao Huaou	Shanghai Semi-island Water Treatment	Shanghai Semi-island Water Treatment	French SIDEM, Simons (China)	Simons (China)		Development Center of Water Treatment Technology

Remarks: electricity 0.35 RMB/kWh, steam 120 RMB/t according to market price; electricity 0.34 RMB/kWh in Weihai; electricity 0.30 RMB/kWh in Dalian; Caofeidian Capital Steel steam 39 RMB/t

Improvement of SWRO technology and engineering realization results into large decrease of energy consumption and cost of water per ton in China. The investment of water per ton is approximately 6000-8000 RMB/t, but the quality of product water is inferior to that in the other two methods (L-T MED and MSF) in the above-mentioned investment conditions. To achieve the same water quality, the cost will increase monotonically. L-T MED is better than MSF in the following aspects such as investment, water factor and power consumption and so on due to high efficient evaporation-condensation heat transfer mode in both sides of heat transfer surface and excellent coefficient of heat transfer. For L-T MED, power consumption of production per ton was usually lower than 1.8kWh, and is about 1kWh according to the latest statistics on some projects at home and abroad at present. So L-T MED is more economic whose investment cost of per ton water 8000-10000 RMB/t under certain conditions.

At present, there are different ideas for the costs of production by seawater desalination. Now in China, special conditions are needed if the cost of production by seawater desalination reaches 5 RBM/t.

Problems about operation costs are rather complicated. Parts are from cost-calculating methods and data sources. For example, both of operation costs of production per ton and actual consumption costs must be in accordance with the actual volume of water production, rather than the productivity due to low operating period. It will be difficult to understand the operation costs of the whole devices if the subsidies including local governmental subsidies such as electrical price subsidies and tax credits as well as staff wages subsidies are directly put into calculation. In addition, the running costs will vary greatly whether there are separate water intake facilities or not (water intake systems account for 15-20% of the total investment). In generally, the self-built water intake systems of power plants and iron and steel enterprises will greatly affect the investment and the operating costs of desalination plant construction. And so is post-processing system (post-processing system, accounting for 10-15% of the total investment). Desalinated seawater which will enter into municipal water supply network must be dealt with water quality post-processing. None would enter into the pipe website but the seawater is converted into micro-scale state, and so on. Moreover, due to the small scale of the most domestic installations (with the economy scale of 100,000 tons / day) and constant fixed cost of each ton of water, it is difficult to decline the cost. According to all aspects of data and analysis, the cost of domestic desalination ton water is between 5-10 yuan. Industrial water supply such as electricity and steel water supply costs around 5 yuan. And the cost of municipal water supply should be close to 10 yuan, which is a little higher. In the case of the cost of state-level desalination projects construction, industrial projects should be urged to impose upon the industrial enterprises to take the way of desalination to resolve the issues, and substantial subsidies should be given for the municipal water supply in order to truly promote the development of the desalination industry.

Energy price is one of the main constituent elements in the cost of desalination. As most devices are built by the way of EPC, the owners mainly rely on its own funds rather than financing or less financing, which makes the cost of financing low. Hence the level of the power consumption in the

domestic play a decisive role in the size of the operating costs, for example, in Qingdao Befesa 100,000 t/d of sea water desalination projects, the negotiations of Spain BEFESA with the Qingdao government was ultimately carried out around the price, and finally the Qingdao Municipal Government via Shandong Provincial Government approved the contract which Qingdao alkali plant of China-owned enterprises provided the internal electricity power price for the company, in order to dissolve the issue of the cost of inversion because the price of water was 4 RMB/t. Therefore, the support for desalination industry could be considered for the desalination of sea water starting with the electricity and steam prices elements, which could guide the reasonable development of industry.

3.5 Construction situation of the key desalination program during the ‘11th five year plan’

Based on the statistics from desalination association on the construction plan in progress current year, by the end of 2008, the gross desalination productivity for China have reached 295,000 m³/d, with 46% growth in comparison of that of former year. What’s more, the productivity of programs under construction have reached 268,000m³/d, and 82,500 m³/d for those in bidding progress or conceptual design. According to incomplete statistics on projects in planning, planning desalination programs in China have reached almost 200,000 m³/d. We are sure that once the time is right major desalination programs will be put into practice.

In 2008, the progresses in key materials and major equipments have also been made, besides the rapid growth in productivity. After the accomplishment of demonstrative 5,000 m³/d single-set RO device, relevant departments are now arranging researchers tackling key problem of desalination program with 12,500 m³/d productivity and design & manufacturing the key whole set distillate devices with independent intellectual property. Meanwhile, the cost of desalination in electric power industry and chemical industry has experienced gradually decreasing, with nominal cost per ton less than 5 RMB. Chinese desalination industry is now fundamentally ready for industrialization. However, the gaps still exist in research level, creativity, manufacture of equipments, design of system and integration. The urgent matters are to solve to problems existing in desalination industry, to improve the technology, to reduce the cost, to upgrade the membrane and membrane materials, to enhance key equipments and to develop new desalination technology with independent intellectual property. Besides, the domestic manufacture rate and the independent ability in manufacturing large scale desalination devices are also very important. In July 2008, China Zhonghe Seawater Desalination Engineering CO. LTD manufactured and exported the first low temperature multi-effect desalination device with independent intellectual property and of 4,500 m³/d productivity to Indonesia, which was an enjoyable threshold of internationalization.

At present the domestic major leading areas of desalination are Tianjin, Shandong, Zhejiang, Dalian, Qingdao and so on. The largest desalination research centers are located in Hangzhou and Tianjin respectively. Technological support play very important role in local desalination industry. In prediction, for the future 5-15 years the annual output value of domestic desalination will be 10 billion yuan and a group of industrialized bases will be formed. Though Chinese desalination

industry is now in growth stage and have promising further, the gaps still exist in the comparison with developed countries and in the demand and supply, in details reflecting in technologies, equipments, standardization and industrialization progress. And also the lacking of fundamental support and system guidance are big problems.

Key projects in 2008:

1. Shougang Jingtang Caofeidian project

Shougang Jingtang united Iron and Steel is located in Tangshan City, Hebei province, and near the seashore of Bo gulf, in Caofeidian industrial areas. The construction scale for project I is 9.7 million ton per year in steel production. Based on the fact of steel factory, and the local situation of water shortage, together with national relevant policies, it was decided to build desalination device to supply the desalted water, soften water and partly new & supplement water. Based on the plan of water [equilibrium](#) of the entire company and the need of desalted water and soften water, low temperature multi-effect desalination with 50,000 m³/d for project I has been chosen, which is divided into two parts, construction scale 25,000 m³/d for each one. The picture shows the construction accomplish of main evaporation device with weight of 565 ton. The breaking through of the key point means the new stage of desalination construction in the company. It is the largest equipment for the company in the process of construction, which is advanced in its comprehensive indexes in comparison with other counterparts. The equipment is large in volume, heavy in weigh and is delivered by three parts. During the transportation, large cargo ship, marine floating crane and large axis vehicle are used. What's more, the requirement of high quality welding increases its difficulties in installation. The construction units have conquered many problems with high quality of welding work with accuracy of 1 mm. According to the person in charge of the project, adjustment work will be done by the end of August, 2008 to supply produced water, and formal water supply will start in 2009, with high quality (near pure water), which can fulfill the requirement of cooling water for iron making, steel making and steel rolling. The application of desalination can save 20 million ton water per year, and provide 18 million ton brinet water for social need.

2. Xinquan seawater desalination project in Dagang, Tianjin

In 2005, Tianjin government made contracts with Singapore HYFLUX company to build desalination project of 100 thousand ton per day, with gross investment of 90 million US dollars. The present largest desalination project is in the form of BOT, financing & building and running by Singapore HYFLUX Company. Based on the fact, though undergone a long time of pre-operation, ground progresses have been done in 2008. At present the progress is smooth, and the instillation & adjustment work will be done by the end of this year. In the first season in 2009, 20 thousand water productions will be available for the Large-scale Ethylene Project. And the water production for project I, based on the design, will reach 100 thousand ton per day, which will be finished by July

2009. By that time, further project II will be scheduled according to the requirement of the Large-scale Ethylene Project. And after the project II, the gross production will reach 150 thousand ton per day. It opens a new era in Chinese BOT in desalination, which is seen as a very important affair in desalination industry in China.

Tianjin Dagang Xinquan Desalination Ltd. CO., its planning construction location is Gujin RD, Dagang District, near the Jing-Qi road and the opposite side of Dagang power plant. Its planning area is 180 mu and total investment is 91.81 million US dollars. It is a matching part of the Large-scale Ethylene Project. With the ground support from Development and Reform Commission of Tianjin, the Tianjin Petroleum and Chemical Corporation says the water demand of the Large-scale Ethylene Project will be totally fulfilled by desalination. The feed water for desalination is the cooling water of Dagang power plant, which is channeled to the desalination plant through Jing-Qi RD. The desalination plant is equipped with double membrane technology as the main parts, advanced RO and energy recycled system are applied to save more energy for desalination process with high recovery rate. At the same time of fulfilling the demands of the Large-scale Ethylene Project, the domestic water in Petroleum and Chemical Industrial Park Dagang will also be provided. As the main part, the Tianjin Petroleum and Chemical 1,000,000 ton per year ethylene project is now properly in progress, together with other supplement projects. And the construction is now accelerating. Since the initiation in March 2007, 166 main parts are all under construction, besides the telecom system and reforming projects delayed by reforming. The RO technology is chosen as the major one, and Project I is to build a desalination device with 100,000 m³/d, planning to finish by the July 2009. And by the end of May 2008, the accumulative investment is 7.228 billion RMB, accounting for 26.97% of total.

3. Tianjin Beijiang power plant 200,000 m³/d desalination project

As the first set pilots of for recycling energy, Beijiang power plant is planning to build 4 sets coal combustion power supercritical units with 1,000,000 KW and desalination device of 400,000 m³/d. Its total investment is 26,000,000,000 yuan. Project I is to build two 1000MW power units and simultaneous a 200,000 m³/d desalination device. Its recycle circle is electricity generating-desalination-brine to salt-saving land-recycle the waste. The project I is planed to be finished in the middle of 2009, with a 100,000 m³/d desalination system. Beijing power plant uses the advanced low temperature multi-effect desalination technology, using the turbine exhausting gas as the heat energy to multi-evaporate and condense, making desalinated water, partly for domestic use, others are used to provide pure water for Binhai new area. The project I can simultaneously provide power and solve the problem for the new area water shortage, earth and environmental stress, like the sinking of earth due to the fresh water exploitation. Further it can improve the upgrade of traditional salt industries and benefit the relevant industries such as building materials and communication.

4. Desalination project of 20,000 m³/d, in Liaoning Hongyan river nuclear power plant Co. Ltd.

The company is consisted by three parts, China Guangdong Nuclear Power Holding Co., Ltd. (45% in share rate), China nuclear power Investment Corporation (45%) and Dalian construction investment corporation (10%), named Liaoning Hongyan river nuclear power Co. Ltd., which company manages the construction and operation of the project I of the nuclear plant. The desalination project is under the EPC form, bided by Wuhan Kaidi & Hangzhou Development Center of Water Treatment Technology, and it applies the RO technology, estimating the finished time is 2008 to supply the construction water and domestic water.

The Liaoning Hongyan river nuclear project I is the first nuclear project in the ‘11th five year plan’ and also is the first nuclear plant in Dongbei area. It is planning to build six nuclear units with 1 million kW level efficiency. And the technical route is based on the pressurized water reactor (pwr) nuclear power route of Guangdong Nuclear Power Company (CPR-1000), which is independently gradually evolved. The No.1 unit of the project started in 18th August 2007, and by the 2012 the commercial operation will be started. The project I of this nuclear plant is playing very important role in link the preceding and the following, in prompting the independence and domestic manufacturing, improving the cultivation of nuclear engineers, upgrading the manufacturing level and accumulating relevant experiences for the million kW level nuclear plants. What’s more, it realizes the standardization, serialization and fulfills the demand of electricity for Liaoning local economic development. Meanwhile it optimizes the grid structure of Dongbei area and revives the Dongbei old industrial base.

5. Zhoushan Liuheng Desalination project

Zhoushan Liuheng Desalination project is the largest domestic municipal water supply project in China, which is carried on by Hangzhou Development Center of Water Treatment Technology, under the umbrella of China National Chemical Corporation. It is contracted by SIDOUMEN engineering corporation and Liuheng Tap Water Co. Ltd, in construction form of EPC. Its total investment is 740 million RBM, with 100,000 m³/d productivity, and it is separated into three stages. The first stage has a scale of 20,000 m³/d productivity with initial investment of 160 million RBM, which will finish in 2008 and plans to provide tap water for society. Hangzhou Development Center of Water Treatment Technology is the main unit of the construction, compared with other counterparts, and it is strong in technical power with 30 years of special experience in water treatment area, especially in municipal water supplying. And the center also have finished many demonstrative projects and have some abilities in equipment manufacture.

Liuheng in Putuo District of Zhoushan City locates in Liuheng Island, which is one of the three largest island in Zhoushan Island. Based on the general planning of the city, Liuheng Island will be developed as the largest port and port based industrial base, which is the key part of total marine economy. However, the lack of fresh water of the island, plus the drought, the need of local people and fishing can not be fulfilled. The fresh water supply is the limitation of local economical

development. Consequently the large scale desalination project is the most proper way to ease the water challenge and enhance sustainable development.

The freshwater is scarcity due to the determination of nature conditions such as the rainfall and geographical conditions in the circumlittoral area of china, which has serious influence on the economic in this area. The central and local government takes a series of measures in order to dissolve the scarcity of water resource, such as the building of reservoir, economization water consumption and recycling waste water, which can relieve the status in a certain extent. However, the conventional measures such as the storage water and inter-basin water transfer and so on can actualize the temporal and spatial distribution but not increase the total water resource on a long view. Inaugurating the new water resource, taking water from the sea, the seawater desalination and seawater direct utilization can dissolve the scarcity of water which is one of strategic choice and basic measure. In order to solve the crisis of freshwater in the coastal area, we must exert the geographic advantage of littoral and choose the approach of the seawater desalination and direct use of seawater.

Evaluate the seawater desalination as the supplement of freshwater resource. First, we should estimate the method of solving the scarcity of water resource. Secondly, the advantage of seawater desalination as supplement and method should be appraised. There are many approaches for solving the freshwater emergency. The primary principle is “inaugurate and economical”. The storage water engineering can be built in the abundance surface water resource area. The inter-basin water transfer should be put in practice in the scarcity surface water resource area. The seawater desalination can be carried out in the circumlittoral area. Moreover, there has the recycle waste water, treatment of water pollution and economical water consumption and so on.

The project of seawater item of Zhejiang province:

According to the principle of “The seawater project of Zhejiang Province in the eleventh five –year plan” and integrating the analytical conclusion of supply and demand balance in every island. The investment is 278 million RBM during the eleventh five-year plan, the scale is 34.5 thousand m³/d, the long-term investment is 258 million RBM. The specific building scale and investment situation can be seen from the

Table 19.

Table 19. The building scale and investment for the seawater desalination

County and city	Short-term scale (m ³ /d)	New investment (×10 ⁴ RBM)	Long-term scale (m ³ /d)	New investment (×10 ⁴ RBM)
Shengsi county	9000	7200	4000	3200
Daishan county	5000	4000	6000	4800
Putuo and dinghai district	12000	9650	13000	10450
Dongtou county	5500	4450	4500	3600
Yuhuan county	2500	2050	1500	1250
Costal area	500	450	3000	2500
Total	34500	27800	32000	25800

3.6 High Concentration Brackish Waste Desalination Project in Cangzhou Chemical Corporation

The system includes 4 RO trains, each with capacity of 4500 m³/d, and the total capacity of 18000 m³/d [23]. The pre-treatment system consists of single stage fine sand multi-media filters. Each pre-treatment system includes 6 filters in parallel with diameters of 3.2 meters and five in operation, one standby. The project was put into operation in October 2000 and commissioned in March 2001.

3.7 Desalination and concentration of dye solution

A nanofiltration plant designed and built by the Development Center of Water Treatment Technology, SOA, Hangzhou, with twelve nanofiltration elements was installed in Shanghai Dyestuff Chemical Plant No.8 in 1993 for the desalination and concentration of dye solution in dye production [3]. The plant is one of the most successful industrial application plant of nanofiltration in China. The plant works well, the performance of the plant is stable, the purity and the consistency of the produced dye are improved. In the past six years, the nanofiltration membrane elements were replaced only once, the service life of the nanofiltration membrane is more than three years. The economic and social benefits of the nanofiltration process are very remarkable.

The nanofiltration process includes two parts: Diafiltration and Concentration.

Diafiltration refers to the process of adding water to the feed dye solution than then permeates through the nanofiltration membrane under certain operating pressure carrying with its salts and impurities smaller than the molecular weight cut-off of the nanofiltration membrane used. The process then used to purifying the dye to ash away the salts and small molecular weight residual by-products of chemical synthesis. The amount of water added depends on the desired purity level in the final product. The higher level in the final product, the more the amount of the water to be added to the system.

The Concentrating part of the process removes water from the dye solution under pressure and thus the dye content can be concentrated to about 30%. The concentration of the dye resulted in significant savings in energy consumption during the drying process, since membrane processes are highly efficient compared to spray drying.

Different kinds of dyes with different molecular weight and structure were produced through the nanofiltration process.

3.8 Sewage Treatment and Reuse

In countries in water shortage, a concept that sewage be valuable water resources is rapidly spreading recently. The traditional idea was that sewage should be treated to serve the purpose of preventing environmental pollution. However, sewage generates in cities where a large amount of

fresh water is needed and the sewage amount is surely proportional to fresh water consumption. It is a stable water resource. Consequently, it is very natural that people pay much attention to reuse treated sewage for new water resources. This new concept is called sewer mining.

Most of reuse plants is based on the so-called “Integrated Membrane Systems” consisting of MF/UF + RO membranes where sewage or secondary treated sewage is undergone activated sludge treatment followed by MF or UF membrane filtration [24]. Then, the filtrate is permeated with low pressure RO membrane for further purification. The permeate is disinfected with UV (Ultra Violet) radiation and introduced to the water reservoir for drinking water where permeate is blended with natural water. It is called NEWater.

3.9 Applications to Industrial Water

Membrane technology is also applied widely in industrial water fields [24].

Factories and industrial products demand various quality of industrial water. When ground water is hard, scaling troubles happen easily, and therefore softening is necessary. Ion-exchange resin was used in the past years, but the process needs regeneration of ion-exchange resin with acid or alkaline chemicals. Recently, softening with NF or RO membrane is getting more and more popular, because the membrane process consumes much less chemicals. When more purity is demanded for high pressure boiler feed or semi-conductor industry, the first step is softening with NF or RO membrane and then further purification is carried out with ion-exchange resin in most cases.

3.10 Research and applications of membrane bioreactor in wastewater treatment and reclamation in China

Membrane bioreactor (MBR) has been attracting increasing attention to its research-development and promising application in wastewater treatment and reclamation since its introduction to China in the midst of 1990s [33]. Till now China has become one of the world’s most active and attractive fields for both academic research and commercial application of MBR. In this section, an insight into the historical development as well as recent situation of MBR in China coupled with a few applied cases, with a future vision also presented will be given.

3.10.1 Research in China

The efforts and achievements on MBR research were summarized based on over 700 literatures about MBR in China Journals Full-text Database and China Doctor and Master Dissertation Database from 1999 to 2006 as well as information from internet. Although it is difficult to cover

all information related, it should be still sufficient to give a comprehensive view of the state-of-the-art of MBR research in China.

3.10.1.a Chronological distribution of journal papers

As is shown in Figure 5, the increase in the amount of journal papers is substantial over the last dozen years, which can be readily divided into three phases: 1) the first is before 1998 as commencement, when the amount of published papers was no more than 11 per year, 2) the second is from 1998 to 2003 referring to developing phase associated with a rapid increment of the amount of papers, indicating MBR became an appealing and hot research subject, and 3) the third is after 2004 which can be described as blooming phase with an output of over 150 papers, when MBR technology have been accepted more widely as a promising technology for water and wastewater treatment. Both research papers and critical reviews present the same trend, indicating the research work on MBR is becoming broader and deeper. The commercial applications of MBR technology in wastewater treatment and reclamation also became popular and more full-scale MBR installations have been constructed in the third phase ([31], [34], [35], [36]).

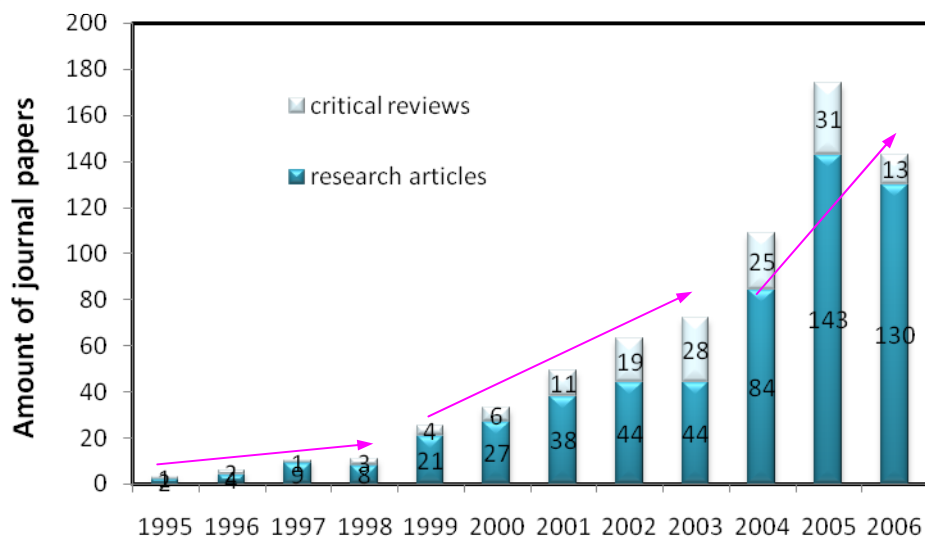


Figure 5. Chronological distribution of literature.

3.10.1.b Research institutes

The distribution and variation of journal papers related to MBR research accomplished by different institutes since 1995 are shown in Figure 6. It can be seen that universities and research institutes are still main body undertaking MBR research in China, contributing to more than 90% of journal papers on MBR. Nevertheless, more and more companies have been attracted to participate in research and development of MBR technology by huge market potentials. This tendency became

more remarkable after 2005. Furthermore most full-scale MBR installations have been designed and constructed by companies, who have made great effort to push MBR industrialization and commercial application ahead. From Figure 7 it can be seen that the amount of total research institutes also increased from 3 in 1995 to about 60 in 2004, indicating the MBR research becoming more active and approaching to a higher level.

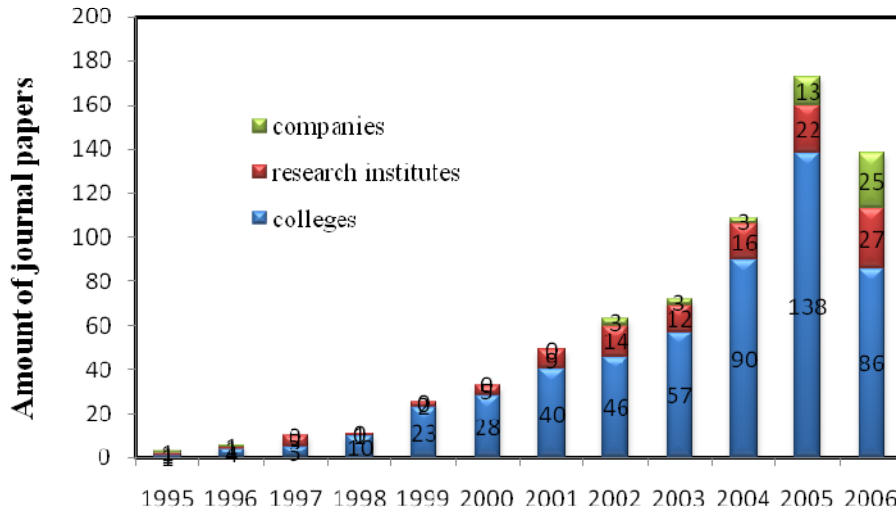


Figure 6. Chronological distribution of journal papers by different research institutes.

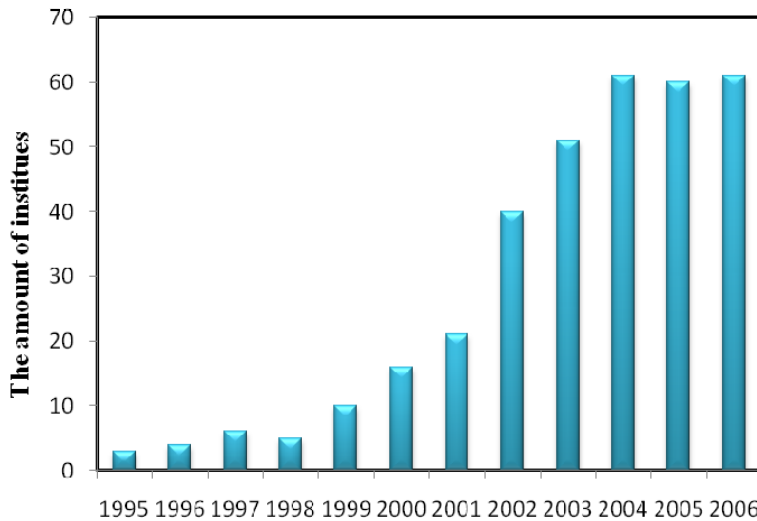


Figure 7. Chronological distribution of institute performing MBR research

3.10.1.c Membrane configurations

MBR systems can be configured in two ways according to the position of membrane module: submerged and external, with the corresponding configurations termed the submerged (immersed or

integrated) MBR and external (recirculated or side-stream) MBR, respectively. Chronological distribution of journal papers on both MBR configurations since 1995 in China is given in Figure 8. External MBR was introduced to China prior to submerged MBR, which is in accord with the course of world MBR research. Submerged MBR was first brought out in 1989 by Yamamoto [10]. After that such configuration was recognized as an alternative for MBR systems. Because of the absence of a high-flow recirculation pump, a submerged MBR system consumes much lower power than an external MBR system does. This energetic advantage allows for the submerged configuration to be more favorable in MBR application and thus in MBR research over the past decade. Meanwhile, journal papers related to external MBR gradually decreased to no more than 5 pieces per year, most of which pertain to specific industrial wastewater treatment or are related to fundamental aspect, such as cross-flow membrane filtration.

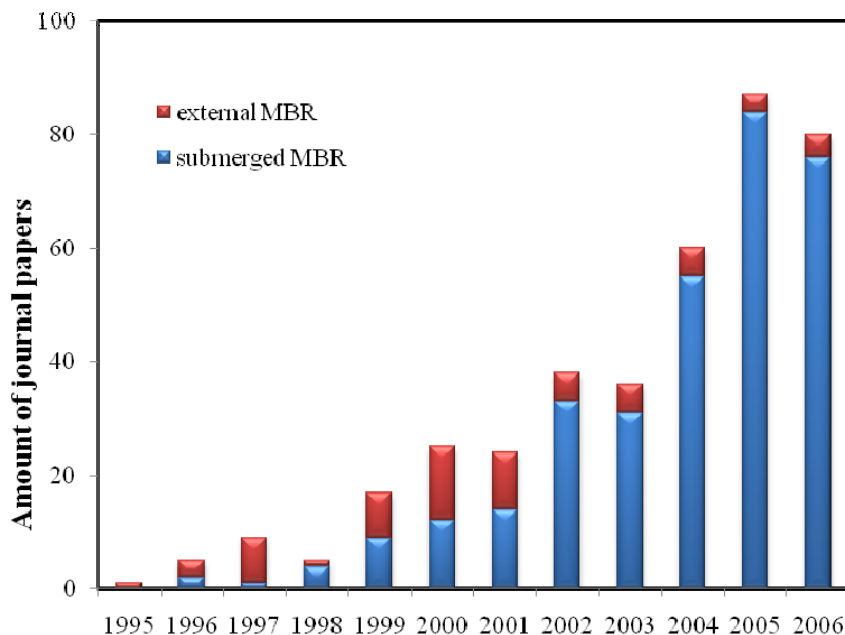


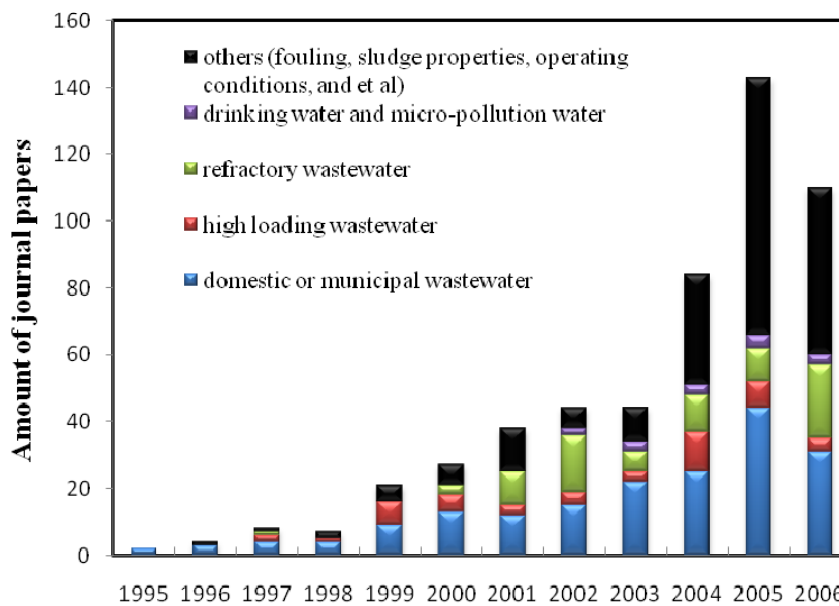
Figure 8. Chronological distribution of journal papers on basis of different MBR configurations.

3.10.1.d Research topics

The chronological distribution of journal papers since 1995 grouped into different research topics is shown in Figure 9. These topics aim at different feeds which include domestic or municipal wastewater, high strength wastewater, refractory industrial wastewater, drinking and micro-polluted water, with fundamental aspect of MBR also taken into account, such as membrane fouling, characteristics and modification of mixed liquor, and optimization of operating conditions. The main research topics on MBR technology in China lie in domestic or municipal wastewater reclamation, membrane fouling control and operating conditions optimization, which may reflect the prevailing application fields as well as the main problems in application.

It should be noted that not only domestic (i.e. municipal) wastewater treatment but also high strength and refractory industrial wastewater treatment has drawn much attention despite of its relatively low proportion in the amount of published papers. Industrial wastewater treatment using MBR demonstrates increasing activity in the most recent years, as can be seen in Figure 9. The performances of typical industrial wastewater treatment using MBR process in China is listed in Table 20.

Figure 9. Chronological distribution of research topics.



3.10.2 Commercial application in China

3.10.2.a General examples

Some examples of commercial MBR installations in China in recent years are given in Table 21. Commercial MBR systems have been applied in both municipal and industrial wastewater treatments (Figure 10), with several of them endowed with the designed scales of up to several kilotons. These facts indicate that the design and operation management of industrial MBR installation in China have reached high levels and the application prospect is more and more promising.

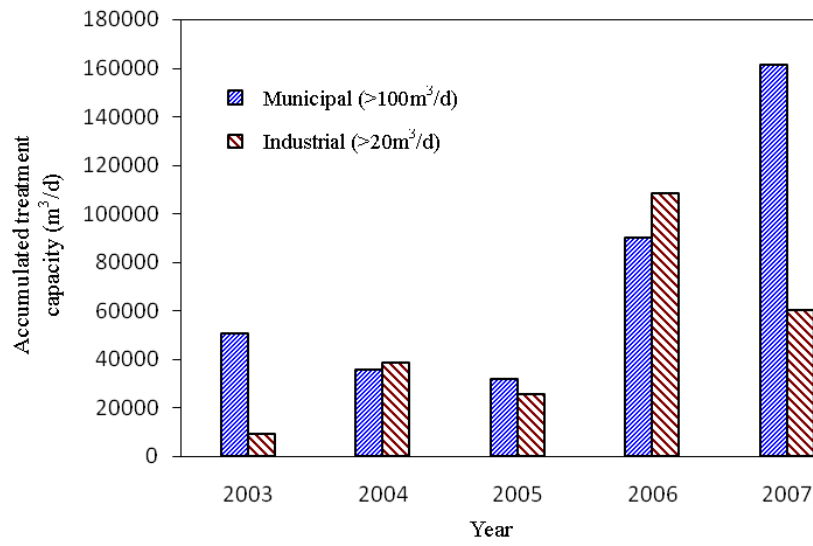


Figure 10. Installation of commencial MBR plants for both municipal and industrial wastewaters.

Table 20. Efficiency of MBR process for specific industrial wastewater treatment.

No.	Wastewater	MBR configuration	Module	Bioreactor	Operating condition	Influent (mg/L)	Effluent (mg/L)	Reference
1	Protein wastewater	Submerged	Hollow fiber	Aerobic	HRT=1.19-3.125 h, SRT=14 d MLSS=5-6 g/L BOD loading=0.3-0.6 kg/kgMLSS·d	COD=623.4-2313.5	COD>95 % TN>61.8 %	[38]
2	Dyeing wastewater	Submerged	Hollow fiber	Anaerobic+ aerobic	HRT=7.6 h	COD=120-250	COD<20 chroma<4	[39]
3	Sauce wastewater	Submerged	Hollow fiber	Aerobic	HRT=10 h MLSS=8-9 g/L	COD=1300 chroma =300	COD=70-97 chroma =40-70	[40]
4	Beer wastewater	Submerged	Hollow fiber	Aerobic	HRT=8-9 h t=24 °C	COD=864-1780 NH ₄ ⁺ -N=34.5	COD<60 NH ₄ ⁺ -N=1-3	[41]
5	Organic wastewater	Submerged	Hollow fiber	Two-phase aerobic	COD loading=5.06-10.12 kg/m ³ ·d	COD=1500-1700 alkalinity=200-300	Acidification rate =60-80 % Gasification rate=80-90 %	[42]
6	Alcohol distillery wastewater	Submerged	Flat sheet	Aerobic	MLSS=8 g/L SRT=60 d COD loading=4.8-6.2 kg/m ³ ·d	COD=26600	COD>95 %	[43]
7	Ramie degumming wastewater	Submerged	Hollow fiber	Aerobic	HRT=13 h	COD=200-2000 NH ₄ ⁺ -N=4-10	COD>85 % NH ₄ ⁺ -N>75 %	[44]
8	High-loading ammonia nitrogen wastewater	Submerged	Hollow fiber	Aerobic	HRT=6 h, SRT=30 d MLSS=6 g/L, NH ₄ ⁺ -N loading=1.11 kg/m ³ ·d	COD=91.18-545.4 NH ₄ ⁺ -N=244.3-440.7	COD=56.7 NH ₄ ⁺ -N=2.88	[45]
9	Slaughterhouse wastewater	Submerged	Hollow fiber	Aerobic		COD=1053 oil=36	COD<40 oil<6	[46]
10	Coking wastewater	Submerged	Hollow fiber	SBR	HRT=32.7 h, SRT=600 d COD loading=0.45 kg/m ³ ·d	COD=400-1000 NH ₄ ⁺ -N=60-130	COD=86.4 NH ₄ ⁺ -N<1	[47]
11	Landfill leachate	Submerged	Hollow fiber	UASB	HRT=1.6-4 d COD loading=1.3-5.7 kg/m ³ ·d	COD=7000-14590 NH ₄ ⁺ -N=2560-2826	COD=65-84 %	[48], [49]

Table 21 Examples of commercial MBR installations for wastewater treatment in China

No.	MBR location	Wastewater	Process	Design capacity (m ³ /d)	Run date
Municipal wastewater (>10,000 m³/d)					
1	Miyun county, Beijing	Municipal wastewater	Secondary effluent→MBR	45,000	2006.5
2	Inner Mongolia	Municipal wastewater	Secondary effluent→MBR	10,000	2006.6
3	Huairou county, Beijing	Municipal wastewater	A/A/O+MBR	35,000	2007.11
4	Beixiaohe, Beijing	Municipal wastewater	A/A/O+MBR	60,000	2007.11
5	Pinggu county, Beijing	Municipal wastewater	A/A/O+MBR	40,000	2008.9
6	Xincheng, Wuxi	Municipal wastewater	A/A/O+MBR	30,000	2009.2
7	Meicun, Wuxi	Municipal wastewater	A/A/O+MBR	30,000	2009.5
8	Shuofang, Wuxi	Municipal wastewater	A/A/O+MBR	20,000	2009.10
9	Shiyan, Hubei Province	Municipal wastewater	A/A/O+MBR	110,000	2009.9
High strength wastewater (>2000 m³/d)					
10	Tianjin	Beer wastewater	Anaerobic+MBR	2,000	2006.5
11	Shandong Province	Slaughterhouse wastewater	Anaerobic+MBR	8,000	2007.6
12	Xuzhou, Jiangsu Province	Tobacco wastewater	MBR+RO	2,000	2007.8
Refractory industrial wastewater (>5000 m³/d)					
13	Luoyang, Henan Province	Petro-chemical wastewater	Anaerobic+MBR	5,000	2002.10
14	Tianjin	Petro-chemical wastewater	Anaerobic+MBR	5,000	2004.6
15	Baling, Hunan Province	Petro-chemical wastewater	Anaerobic+MBR	7,200	2005.10
16	Jinling, Jiangsu Province	Petro-chemical wastewater	Anaerobic+MBR	6,000	2005.11
17	Hainan Shihua, Hainan Province	Petro-chemical wastewater	Anaerobic+MBR	10,000	2006.11
18	Dayawan, Guangdong Province	Petro-chemical wastewater	Anaerobic+MBR	25,000	2007.2
Landfill leachate (>400 m³/d)					
19	Fushan, Guangdong Province	Landfill leachate	Anaerobic+MBR+NF	900	2006
20	Likeng, Guangdong	Landfill leachte	Anaerobic+MBR+NF/RO	900	2006
21	Yangluo, Hubei Province	Landfill leachte	Anaerobic+MBR+NF/RO	400	2006
Polluted river					
22	Beijing	Polluted river	Coagulation+MBR	100,000	2007.10

3.10.2.b Case studies

Miyun municipal wastewater MBR Plant, Beijing

Miyun is located in the northern suburb of Beijing and served as the main water resource region for Beijing. For the sake of water resource protection, Miyun MBR plant was constructed based on the already existing municipal wastewater treatment plant in May, 2005. MBR process was adopted to treat the secondary effluent of the existing wastewater treatment plant in order to ensure the quality of final effluent meet water quality standard for scenic environment use. The establishment of Miyun MBR plant has not only solved the problem that the effluent of the existing wastewater treatment plant was not able to meet the relevant discharge standard, but also eliminated the pollution threat to groundwater resource. At the same time, reclaimed water can be used to improve the water environment of Chaobai River. The scheme of the process, photos of membrane tank and more details of the project are given in Figure 11, Figure 12 and Table 22, respectively.

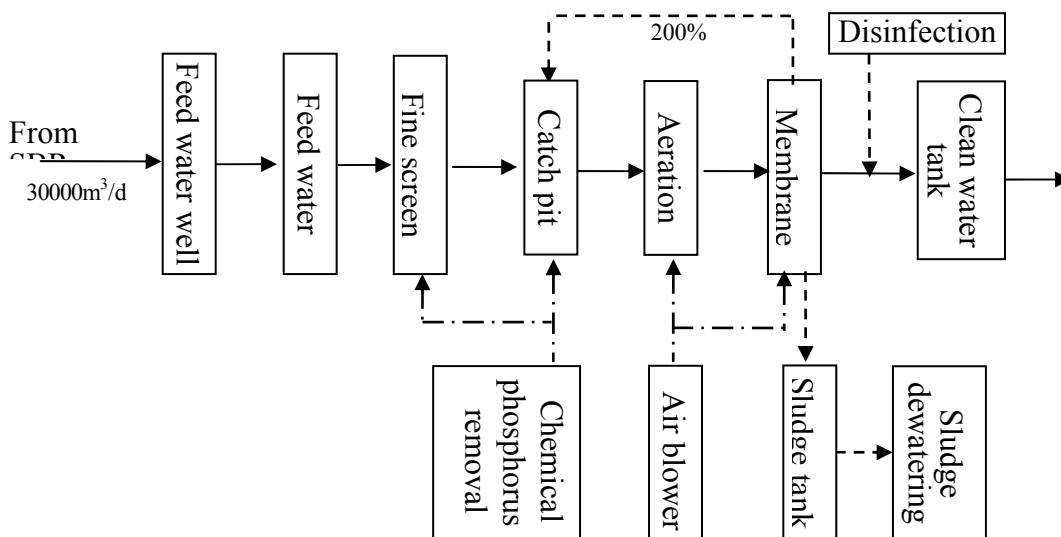


Figure 11. Schematic process of Miyun municipal wastewater MBR Plant, Beijing



Figure 12. Photos of membrane tank in Miyun municipal wastewater MBR Plant, Beijing.

Table 22. The details of Miyun municipal wastewater MBR Plant, Beijing.

Items	Content
1. Membrane parameters	
Supplier	Mitsubishi Rayon, Japan
Material	PVDF
Configuration	Hollow fiber in flat shape
Pore size	0.4 μ m
Area of single piece	25m ²
Piece number of one unit	60
Area of one unit	1500 m ²
2. Membrane unit treatment capacity in the first term	
Designed maximum flux	30L/m ² .h
Unit number of membrane module	28
Total area	42000m ²
Maximum effluent	1260m ³ /h
3. Influent and effluent qualities of MBR	
Influent quality of MBR	
COD	80~300mg/L
NH ₄ ⁺ -N	30~80mg/L
TN	50~110mg/L
TP	1~4mg/L
SS	50~120mg/L
Effluent quality of MBR	
COD	8~70mg/L
NH ₄ ⁺ -N	0~4mg/L
TN	40~90mg/L
TP	0.5~3mg/L
SS	undetectable
4. Operating situation of MBR	
MBR-HRT	4h (including aeration and membrane tanks)
MLSS of membrane tank	7~15g/L

MBR process used in Miyun reused water plant is the advanced wastewater treatment technology in the world nowadays. Miyun reused water plant is one of the largest-scale water reuse projects of MBR process in Asia.

The MBR wastewater treatment plant of Golden Bridge power plant, Hohhot

Golden Bridge power plant is located in Hohhot with a planning capacity of 4 × 300 MW power sets. In view of water resource shortage and huge amount of water demand of the plant, the utilization of recycling water has been incorporated into the government's plan. Thus the effluent of Xinxinban wastewater treatment plant (Xinxinban WWTP) is to be further treated further into recycling water so as to be used as industrial water in the power plant.

The conventional activated sludge process is applied to treat domestic wastewater and industrial wastewater of Hohhot in Xinxinban wastewater treatment plant. The effluent goes along a transport pipe line into the recycling water plant located in Golden Bridge power plant 12 km away from Xinxinban WWTP. The MBR + weakly acidic hydrogen cation exchange comprises the main process of the recycling water plant with more details illustrated in Figure 13. The recycling water production is 30,000 m³ per day and the recycling water is used as circulating cooling water of the power plant with more information about the plant provided in Table 23. The scene of the membrane tank is given in Figure 14.

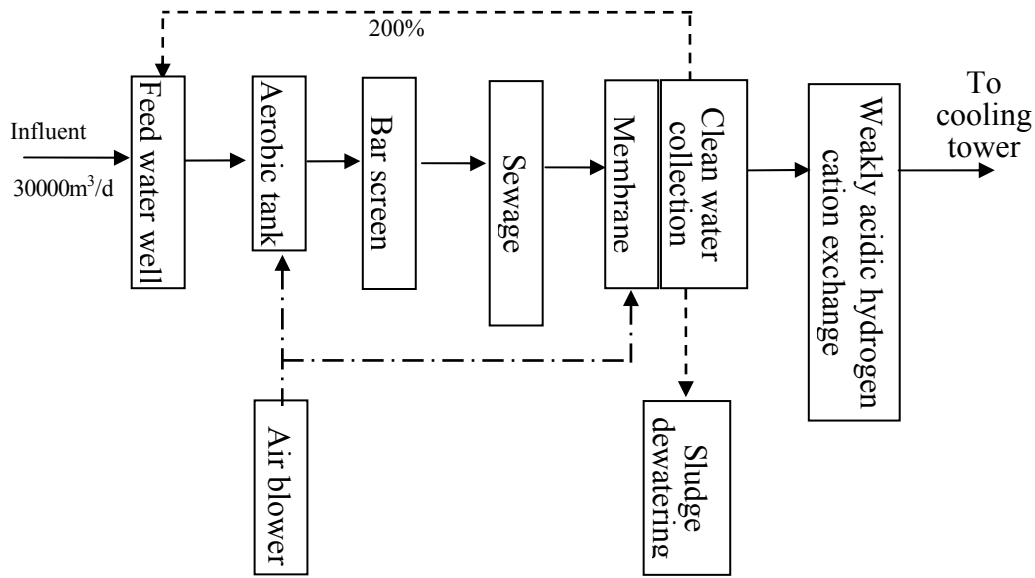


Figure 13. Schematic MBR process in Golden Bridge power plant, Hohhot.



Figure 14. The membrane tank in Golden Bridge power plant, Hohhot.

Table 23. The details of the MBR plant in Golden Bridge power plant, Hohhot.

Items	Content
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1. Membrane parameters	
Supplier	Zenon, Canada
Material	PVDF
Membrane module configuration	Hollow fiber in flat shape
Pore size	0.04 μm
Area of single piece	32 m^2
Piece number of one unit	44
Area of one unit	1500 m^2
Unit number of membrane module	42
2. Treatment capacity	
Designed maximum flux	26.5 L/(m^2 .h)
Total area	58000 m^2
Maximum effluent	35000 m^3/h
Investment of construction	85 million Yuan
Present operating situation	Continuous operation on the rails
3. Influent and effluent qualities of MBR	
Influent quality of MBR	
COD	80~200mg/L
NH_4^+-N	10~35mg/L
TP	0.5~2mg/L
SS	20~50mg/L
Effluent quality of MBR	
COD	20~50mg/L
NH_4^+-N	0~3mg/L
TP	0.2~1mg/L
SS	undetectable
4. Operating situation of MBR	
MBR HRT	3.2h (including aerobic tank and membrane tank)
MLSS of aerobic tank	5~12g/L
Membrane cleaning method	On-line NaClO cleaning and air cleaning

The MBR wastewater treatment plant in China Petrochemical Co Ltd Jinling Branch, Nanjing

China Petrochemical Co Ltd Jinling Branch (Jinling in brief) is situated in the northeastern suburb of Nanjing City bordering the Changjiang River. Jinling is a modernized national super-huge petrochemical integrated enterprise and the scope of its business mainly covers oil refining and production and sales of petrochemicals with its more than 40 processing units covering crude refining, chemical fertilizer production, thermal power generation, etc.

The amount of oil refining wastewater of Jinling is 25,000 m^3/d , treated by three wastewater treatment installations, including two traditional activated sludge process installations and one MBR installation with the capacity of 5,000 m^3/d . The scheme of the process, photo of membrane tank and more details of the project are given in Figure 15,

Figure 16 and Table 24, respectively.

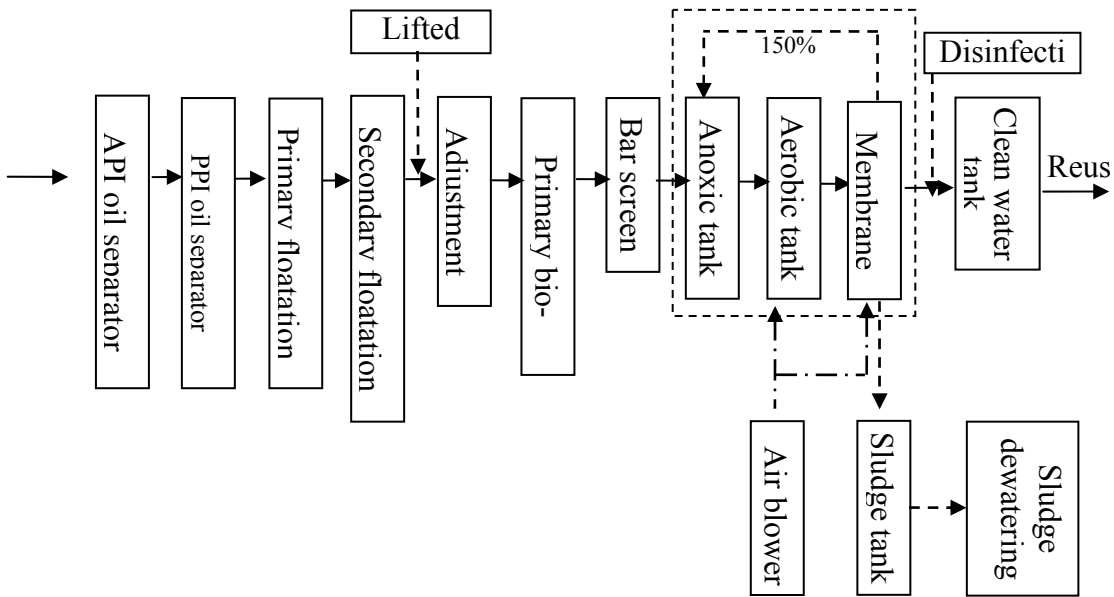


Figure 15. Schematic MBR process in Jinling, Nanjing.



Figure 16. The membrane tank in Jinling, Nanjing.

Table 24. The details of the MBR plant in Jinling, Nanjing.

Item	Content
1. Membrane parameters	
Supplier	Motimo, Tianjin
Material	PVDF
Membrane module configuration	Hollow fiber in plat shape
Pore size	0.02 μ m
Area of single piece	20m ²
Piece number of one unit	40
Area of one unit	800 m ²
Unit number of membrane module	24
2. Treatment capacity	
Designed maximum flux	15L/(m ² .h)
Total area	19200m ²
Maximum effluent	250m ³ /h
Investment of construction	25 million Yuan
Present operating situation	Continuous operation on the rails
3. Influent and effluent qualities of MBR	
Influent quality of MBR	
COD	120~300mg/L
NH ₄ ⁺ -N	10~40mg/L
TN	20~50mg/L
TP	<0.2mg/L
SS	30~120mg/L
Effluent quality of MBR	
COD	40~80mg/L
NH ₄ ⁺ -N	0~7mg/L
TN	10~30mg/L
TP	<0.2mg/L
SS	undetectable
4. Operating situation of MBR	
MBR -HRT	16 h (including anoxic, aerobic and membrane tanks)
MLSS of membrane tank	3~8 mg/L

3.10.3 Future vision in China

3.10.3.a Challenges

Although great achievements have been obtained on both academic research and commercial application in China over the last dozen years, there are still challenges to increase the competitiveness of MBR technology and broaden the market. The main challenges include:

(1) Improvement of membrane materials and modules

Membrane material with the features of long service life, high physical strength, anti-fouling ability and reasonable cost, should be further developed. Especially, the research and development of Chinese local membrane material should be greatly promoted since in most of commercial applications of MBR, foreign membrane modules are still dominant.

(2) Control strategies of membrane fouling

Membrane fouling control is a long-term task for MBR technology, which should be studied continuously and further. The methods of mathematical modeling, colloidal chemistry, molecular biology and other microcosmic methods should be employed for the investigation into membrane fouling mechanisms.

(3) Further decrease of energy consumption

The energy consumption of MBR process has already decreased greatly when submerged configuration substituted for external configuration. However, MBR process still consumes more energy than traditional treatment processes. It is necessary to decrease the energy input further in order to increase the competitiveness of MBR.

(4) Optimization of MBR processes

The total system of MBR should be optimized to both ensure long-term stable operation and satisfy the water quality of effluent.

(5) Scaling up of MBR installations

The MBR installation scale should be enlarged and the application field should be widened, especially for high strength and refractory wastewater. Necessary pre-treatment process should be set up to reduce membrane fouling and avoid operation failure in so far as possible.

3.10.3.b Future work in promising application fields

Municipal wastewater reuse

MBR process has been widely used for municipal wastewater reuse. It is worthwhile to undertake some work in the future, corresponding to the accelerating MBR application. The future work includes:

(1) Summarization and generalization of the designing and operating experiences of large-scale MBR installations need to be implemented for the sake of the scaling up of MBR installations.

(2) Removal of newly considered pollutants, such as EDCs and PPCP, is worth trying using MBR processes in order to guarantee the safety of reused water. For example, combination process of MBR, NF and biological activated carbon adsorption can remove EDCs efficiently, such as Nonylphenol and Bisphenol-A [57].

(3) The design guidance of MBR process for municipal wastewater treatment needs to be established.

(4) MBR + RO (or NF) process should be paid attention to in future ascribed to increasing demand of high quality water for reuse. Both RO and NF are efficient to remove solutes in the water and

MBR can be used as pre-treatment process. MBR + RO or MBR + NF process have been brought forward to treat sewage and the effluent utilized as non-drinking pure water [58].

Industrial wastewater treatment and reuse

MBR process has also been utilized in some kinds of industrial wastewater treatment whereas it is not enough. MBR has superiority to traditional treatment process when removing refractory pollutants due to the high biological diversity and effective rejection of pollutants in MBR. More wider and popular application of MBR process in industrial wastewater treatment should be expected. The combination of MBR process with other process, such as physical process, chemical process as well as bioaugmented process, should be focused on the industrial wastewater treatment. In addition, the possibility of more serious membrane fouling should be considered because the composition of industrial wastewater is more complicated.

Purification of drinking water source

MBR process can be a sound substitute for coagulation, sedimentation and filtration of the conventional treatment process and used for drinking water treatment. MBR process can also be employed for purification of drinking water resources, especially for treatment of micro-polluted water resources and denitrification of groundwater.

4. Future development of membrane research and application in China

The research development and application on membrane science and technology in China has got much progress since the beginning of 1960s, but the fundamental studies on membrane materials, mechanism of membrane formation and transport in membrane are very insufficient. In order to lay a good foundation for further development, it is necessary to pay much attention to the fundamental research, and to the international exchange and cooperation. At the same time, combining the research with application makes the research results get practical use quickly.

The utilization of membrane technology in Chinese food industry is still very limited. It is commonly used in water treatment, part of juice production and enzyme preparation, its usage in other fields is not much. Most part of advanced facilities is made in foreign countries. Only if membrane industry, industrial field and food industry will cooperate together, it will be possible to develop more and better membrane module and facilities according to the characteristics of the different techniques and products. Then, these facilities could be applied to the food industry and replace imported equipments. This will make Chinese conventional industry more prosperous, satisfy the increasing demand of people's living level and do great contribution to the peace and stability of the world. In fact, membrane technology can be regarded as one of the main means for recycling economy and promoting traditional industry, capable of obtaining remarkable reward in economical, social and ecological yields.

Present interest on membrane field is also well documented by the existence of several journals. For example, China Blue Star (Group) Corporation and its subordinate enterprises and research institutes have sponsored some academic periodicals with a widespread influence in the sector. These periodicals have made contributions to the exchange and technical progress in their respective sectors and also created a favourable environment for their own research and development. These periodicals include:

“Membrane Science and Technology”, “Plastic Industry”, “Organic Silicon Materials”, “Separation of Natural Products”, “Chemical Minerals and Processing”, “Aging and Application of Synthetic Materials”, “Cleaning World”.

5. MIAC and CDA: non-profit organizations dedicated to the development, promotion and appropriate use of membrane technology

The Membrane Industry Association of China (MIAC), State Administration of Petroleum and Chemical Industry (SAPCI), the Chinese Academy of Science and State Oceanic Administration, registered with Ministry of Civil Affairs of People’s Republic of China in 1995. It is a social association formed freely by the unites of the membrane industry in China, also is a national association throughout different regions, departments and do not get the profit. The Membrane Industry Association of China belongs to Ministry of Chemical Industry of the People’s Republic of China (MCI), and its purpose is to service the members, to preserve the proper profit of its members, to carry on the rules and policies of the country, to strengthen the communication and cooperation of the members, to operate the research and apply of technology and science , to boost the advancement of the members’ future, to increase the economy effect of the members and to promote the members’ development.

The Membrane Industry Association of China has 240 members at present and they can provide the research, design, production, sale of many kinds of membrane science and technology. They cover over 80% of membrane industry in China including Joint Ventures and Institutes.

The Chinese Desalination Association (CDA) has now been officially recognized at the Congress in Singapore [21]. The IDA (International Desalination Association) Board officially recognized the newly formed CDA as the latest organization to complete the formalities to become a regional affiliate. The CDA joined with a mix of both corporate and individuals members, several of whom attended the Congress. This first step will increase the reach of IDA into China with a local affiliate. In 2004 a group of IDA representatives supported the first IDA Desalination Forum in Tianjin and there are plans to organize another event in Tianjin in 2006.

6. Some of the most relevant events on membrane operations in China

MIAC and other organizations have been active in the last years and will be active in future in organizing specific conferences, workshops and exhibitions on membrane operations. The most representative are in succession summarized:

1. First EU – China Summer School on Membrane Science and Technology, held in Lanzhou, Gansu, on August 1986
2. Summer School on Membrane Science and Technology, held in Nantong in 1988
3. EEC China Workshop on Preservation of Cultural Heritages, Xian, Shianxi, P.R. of China, Sept. 25-30, 1991
4. International Symposium on Membranes and Membrane Processes, Hangzhou, P.R. of China, April 5-10, 1994
5. Second joint China/USA Chemical Engineering Conference, Vol. I, Beijing, China, May 19-22, 1997
6. The International Conference on Membrane Science and Technology (ICMST '98) held in Beijing on June 9 - 13, 1998
7. The 21 Century International Symposium on Membrane Technology and Environmental Protection held in Beijing on September 19-22, 2000
8. China - Italy - Workshop on "Membrane Process for Clean Production and for Sustainable Industrial Growth", April 9-11, 2001, Beijing
9. Sino-Italian Meeting for Applying for EU-China S&T Projects, sept. 4-5, 2001, Beijing
10. 2001 International Conference on the Application of Membrane Technology, Shanghai, China, 17-20 Sept. 2001
11. 1st Workshop Italy-China on "State of Research and Applications of Membrane Operations for a Sustainable Growth", Cetraro, Italy, 1 - 4 July 2002
12. The 2nd International Conference on Application of Membrane Technology, Sept. 27-29, 2002 International Convention Center, Beijing, China
13. China/Italy Workshop on "The Technology of the High Quality Wine Production", Oct.. 29-30, 2002, Beijing, China
14. A Sino-Italian Seminar on Dairy Products Technology, Weihai, 3- 5 March 2004
15. Intensive Membrane Course held at the Jiangsu Polytechnic University (JPU), Changzhou (China), June 1 - 10 2005
16. "Sino-Italian Training Course of the Membrane Technology Usage in Food Processing Industry" held in Weihai, China, July 4 –7, 2005
17. International Forum on Water Industry - IFWI 2005 held in Qingdao, China, July 8-10, 2005
18. Water & Membrane China (Shanghai) 2006, Shanghai, March 29-31, 2006.
19. Sino-Italian Conference and Training Course on Membrane Technology, organized byITM-CNR, Weihai Science & Technology Bureau, Weihai Science & Technology Exchange Center and the Harbin Institute of Technology, Weihai, 28 June – 1 July 2006.

20. 2007 Asian Conference on Desalination & Water Reuse, Qingdao, July 4-6th, 2007.
21. China-EU Seminar on the Application of Membrane Technology & Cooperation Fair, July 8 - 12, 2007, Weihai.
22. First Sino-EU International Workshop on Membrane Technology, Weihai, October 13 -15, 2008, supported by the Chinese Ministry of Science and Technology (MOST), Shandong Provincial Department of Science and Technology, Weihai Science and Technology Exchange Center with Foreign Countries and the Harbin Institute of Technology, in collaboration with the Institute on Membrane Technology and the European Membrane Society.

7. Some of the institutions involved in membrane research and development in China

A partial list of research institutions directly involved in membrane science and development is as follows:

- Zhejiang University
- Beijing Research Institute of Chemical Engineering and Metallurgy
- Changchun Institute of Applied Chemistry, Chinese Academy of Science - CAS
- Northwest University in Xi'an
- Institute of Chemistry the Chinese Academy of Sciences (ICCAS) in Beijing
- Citrus Research Institute of Chinese Academy of Agricultural Sciences (CAAS) in Beibei
- Xi'an Jiao Tong University
- Chinese Academy of Sciences, Beijing
- Jiangsu Polytechnic University (JPU) in Changzhou
- Chongqing University
- Tianjin University of Science and Technology
- Development Center of Water Treatment Technology (Hangzhou)
- Weihai Science & Technology Bureau
- Weihai Science & Technology Exchange Center
- Harbin Institute of Technology
- Ocean University of China
- Tsinghua University
- National Taiwan University, Taipei
- National Engineering Research Center of Urban Water Resources
- Tongji University
- Xi'an Architecture and Engineering University
- Chinese Research Academy of Environmental Science
- Beijing Institute of Environmental Protection

- National Engineering Research Center of Water and Wastewater Engineering
- Dalian Institute of Chemical Physics State Key Laboratory of Catalysis

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Membrane producers in China

From web-sites (such as www.eco-web.com/index/category/3.6.5.html and <http://www.made-in-china.com/products>) and other sources (such as Water and Membrane China 2004 - Official Catalogue, Water and Membrane China 2005 - Official Catalogue, Water & Membrane China (Shanghai) 2005 - Exhibition Catalogue), the following membrane producers and distributors have been individuated:

1) American Membrane Corporation (AMC)

Street: 1701 West Beijing Road #2209

City: Shanghai 200040

Tel: (+86) 21 - 5108 2131

Fax: (+86) 21 - 5157 2155

E-mail: sales@americanmembrane.com

Internet: www.americanmembrane.com

Activities: **Microporous Membranes for a Wide Range of Applications, PES, PVDF, NT, PP**

Roll Stock and Cartridges

2) Ande Membrane Separation Technology & Engineering (Beijing) Co., Ltd.

Post Code: 101300

Tel: +86-10-80482249 80482250 80482251 80482252

Fax: +86-10-80482253

E-mail: andemem@public3.bta.net.cn

ANDE Membrane Separation Technology & Engineering (Beijing) Co., Ltd. Is a foreign capital enterprise that engaged in marketing, manufacturing and after sale service for membrane separation technology. It offers both membranes and systems for the followings:

- Ultra pure water system for Semi-conductors/Electronics Industry
- UF, EDRO, RO and Anode systems for E-coat paint in automobile and appliance industry
- Various UF/NF/RO membrane systems for purification, concentration and separation application in Food/Biotech/Beverage Industries
- Drinking water and pure water systems
- RO/DI/EDI Integrated application systems
- Central security monitor, PLC
- Oil water separation system
- MF/UF/NF/RO Spiral modules
- Tubular membrane,
- Filter cartridges
- Flat membranes modules

It is the objective of management to develop the application of Ultrafiltration, Nanofiltration and Reverse Osmosis in every industry.

3) Asahi Kasei Chemicals Corporation

Post Code: 100-8440/200020
Tel: +81-3-35072682/86-21-53513528
Fax: +81-3-35081474/86-21-63916607

<http://www.asahi-kasei.co.jp/membrane/inaexhtml>

Asahi KASEI, one of the leading chemicals companies in Japan, is also a world's leading company in membrane technology having a wide variety of membrane products.

Asahi KASEI contributes to human life and living through environmental protection, energy saving and health care by supplying excellent membrane technology such as hollow fiber type ultrafiltration and microfiltration (microza ® UF/MF).

“microza ® MF” provides high pathogen and suspended solid removal while producing high level of flux with excellent stability by utilizing reverse filtration and air scrubbing. In addition, physically tough and chemical resistant PVDF membrane allows cleaning with high concentration of chemicals and frequent air scrubbing while ensuring a long lifetime.

“microza ® MF” module is used by many customers all over the world for water treatment process, for example, production of municipal drinking water, reuse of sewage, pre-treatment of RO, pre-treatment for desalination of seawater, etc.

4) Beijing Dingchuangyuan Membrane Technology Development Co., Ltd.

Post Code: 102300
Tel: +86-10-69839161/69839162/69839163
Fax: +86-10-69838055
E-mail: liang@chinadcy.com
<http://www.chinadcy.com>

This is a new water treatment products provider, mainly engages in the manufacture of membrane and relative products.

5) Beijing EDI water-treatment technologies,ltd

Address :rE2305 jinyu international plaza 48 west wangjing road changyang district,Beijing
PC : 100102
Tel : 86 10 64787281
Fax :86 10 64787279
Email : sales@canpure.com
Website : www.canpure.com

Beijing EDI water-treatment technologies,ltd is a provider of membrane technologies and products. the membrane products provided include canfil MBR membrane modules,savier aerated outside-in UF membrane elements,savier inside-out UFmembrane elements,canpure EDI membrane modules,and canpure DC power units.

6) Beijing Orient-Era Water Treatment CO., LTD

Post Code: 100080
Tel: +86-10-63848536/13601106857
Fax: +86-10-63848684
E-mail: shazk@sohu.com
<http://www.oewater.com>

The main technology of this company is focused on filtration. The filter it supplies is a kind of high capacity PCF fiber filter with super-high flow rate, high precision, and adjustable holes. It can be completed back-washed. The main advantages of this fiber are stable, resistant to strong acid and alkaline, non-biodegradable. It can be used in ultra filtration, waste water treatment, reclaimed water reuse, cooling water filtration, feed water treatment, and coal water treatment.

7) Beijing Tri-High Membrane Technology Co., Ltd.

Post Code: 100085

Tel: +86-10-82715570/81157137

Fax: +86-10-62843557

E-mail: trihigh@163.com

<http://www.trihigh.com.cn>

This is a professional manufacturer and provider of high quality water treatment products with the core of membrane technology.

Tri-High's pressure vessel, UF hollow fiber membrane, Quartz silicon sand as filter media, anthracite, etc have gained a good reputation in the world, especially its PS* hollow fiber membrane due to its good performance.

Key products:

- RO pre-treatment
- UF membranes
- FRP pressure vessels
- Quartz sand silicon and anthracite filters.

8) Beijing Memsep Technologies Co., Ltd.

Address: No. 10A, Longqing St., Beijing Economic and Technological Development Area, Beijing 100176, China

Tel: +86-10-67871470/71/72

www.memsep.com

Memsep is a high-tech company focussing in the development and application of modern separation and bio-chemical technology. Development of inorganic ceramic membranes, several patents and special know-how also in seawater desalination technology.

- Jilin Fuel Ethanol production from corn with capacity of 600,000 tons/year, technical consultation
- 30,000 tons/year L-Lactic acid fermentation and membrane separation technology
- Hainan Golden Coconuts Company 50,000 tons/year of beer transfer yeast, process improvement and investment consultation
- BOC (Beijing) 10 tens/hour Ultra-Pure Water generation with membrane separation equipments

Process:

- Inorganic ceramic membrane technology
- Seawater desalination RO technology

Products:

- The agent of TAMI Industries (France)

9) Beijing Memshell

http://www.memshell.com/ke_en.htm

Beijing Memshell Technology CO., LTD. is a high technological company that is primarily concentrate on the water environment protection. The main business is divided into two parts: Production department mainly sales water treatment production, instrument and apparatus, consuming material of water treatment engineering; Engineering department responds to accept the total project design of water treatment engineering and business packing etc.

10) Beijing Zhong ke Membrane Technology Co., Ltd.

Address: Number 18, Shuangqing Road, Haidian District, Beijing 100085, China

Tel: +86-10-62849322

www.zhongkemo.cn

Process:

- UF, MBR

Products:

- Manufacturer of membrane and modules

- UF spiral-wound module

Type	Dimension [mm]	Material	MW [cut-off]
4040	Φ100×1050	Polymer blend: PES, PAN, PS, PVDF	3000~300000
6040	Φ148×1050	Polymer blend: PES, PAN, PS, PVDF	3000~300000
8040	Φ196×1050	Polymer blend: PES, PAN, PS, PVDF	3000~300000

- UF Hollow-fiber module

Type	Dimension [mm]	Material	MW [cut-off]
4040	Φ90×1122	Polymer blend: PES, PAN, PS	1000~300000

11) Beijing Tri-High Membrane Technology Co Ltd (THMT)

RO Pressure Vessels, UF Membranes, FRP Tanks, Filter Media, Ion-Exchange Resins, PP Filters and Housings; Water Supply & Purification - Water Filtration: Filtration Processes, Filter Media and Elements, Sand Filters, Microstrainers, Carbon Adsorption - Membrane Processes: Reverse Osmosis, Electrodialysis, Ultrafiltration, Nanofiltration - Demineralization: Desalination, Distillation, Solar Humidification, Vapour Compression, Evaporation.

Building: Baiyan Mansion #406

Street: 238 Beisihuan Zhonglu

District: Haidian

City: Beijing 100083

Country: [China](#)

Tel: (+86) 10 - 8271 5570 / 82327451

Fax: (+86) 10 - 6284 3557 / 82327451

E-mail: membrane@trihigh.com.cn

Internet: www.trihigh.com.cn

Activities: **RO Pressure Vessels, UF Membranes, FRP Tanks, Filter Media, Ion-Exchange Resins, PP Filters and Housings**

12) Changcheng Xinyuan Gw-Ncmt Co., Ltd.

Post Code: 230601

Tel: +86-551-3830019

Fax: +86-551-8997332

E-mail: ncmhf@mail.hf.ah.cn

Changcheng Xinyuan (Great Wall New Century) Membrane Technology Corporation Ltd (GW-NCMT Co Ltd) is a high-tech corporation set up in 2000. The corporation involves the scientific research, design, production, engineering installation, debugging tracing and technical service. It combines and utilizes adequately the superiority of a strong listed company and a first-class university in China.

13) Chanitex (Shangai) Pure-Water Equipment Co., Ltd.

Post Code: 201103

Tel: +86-21-64653149

Fax: +86-21-64061926-803

E-mail: chanitex@chanitex-sh.com

<http://www.chanitex-sh.com>

Chanitex (Shangai) Pure-Water Equipment Co., Ltd., located in the city of Shangai, is an exclusively foreign owned enterprise.

Its products are used in the field of water purification, beverage, electron, brew, boiler and food industry for their perfect design, stable performance and high quality. The core product of this company is the RO system.

14) China National BlueStar (Group) Corporation

Address: No. 19, East Road, North No. 3 Ring Road, ChaoYang District, Beijing 100029, China

Tel: +86-10-64429448

www.china-bluestar.com

Process:

- RO, UF, MF

Products:

- Be authorized to sell FILMTEC reverse membrane of DOW and the membrane shell of Codeline (America)

A group of industry associations and organizations in the chemical industry are anchored to China Blue Star (Group) Corporation and its subordinate enterprises. These associations and organizations have made a lot of contributions to the formulation of industrial standards, the acceleration of the development of their respective sectors and the promotion of information communication and technical exchange between domestic and foreign chemical enterprises.

These industry associations and organizations include the following membrane industries: Membrane Industry Association of China, Seawater Desalination and Resources Comprehensive Utilization Society of China, National Liquid Membrane Engineering and Technology Center

15) Dalian Puricle Products Co., Ltd.

www.puricle.cn

Tel: +86-411-84820819

Address: No. 782-2, HuangPu Road, Dalian 116025, China

Process:

- Gas membrane separation
 - OEA
 - VOC's
- PV, VP

Products:

- Manufacturer of OEA module
- membrane module and system Supplier

16) Dalian Eurofilm Industrial Ltd.

Address: Guangrong Building, No 90, Xi'an Road, Dalian 116021, China

Tel: +86-411-84509181

www.eurofilm.com.cn

Process:

- UF, VOC's separation, H₂ recovery

Products:

- Membrane separator and unit supplier

17) Dalian Eurovapor Industrial Ltd.

Address: Guangrong Building, No 90, Xi'an Road, Dalian 116021, China

Tel: +86-411-84507531

www.eurovapor.com

Process:

- gasoline vapour recovery at tank farm, loading terminals and petrol stations

Products:

- unit supplier.

18) Dalian OKM Industrial Ltd.

Post Code: 116021

Tel: +86-411-84509282/84509283/84509310

Fax: +86-411-84508895

E-mail: okm@okm.com.cn

www.okm.com.cn

Dalian OKM Industrial Ltd. is the exclusive co-operator of Membrane in China, which is responsible for sales and technical support in this area.

Membrana (Germany), located in Wuppertal, is one of the largest independent membrane producer world-wide and:

- one of the largest suppliers of hollow fibre dialysis membranes;
- the world's largest supplier of flat sheet microporous membranes;
- the first and the only producer processing of patents and technical know-how of producing PP membranes in hollow fibre-configuration based on thermally induced phase separation (TIPS) technology;

- the first producer processing of patents and technical know-how of producing hydrophilic UF membranes in hollow fibre-configurations through the blend of PES and PVP.

19) Darlly Filtration Equipment Co.,Ltd,

<http://www.darlly.cn>

Darlly Filtration Equipment Co.,Ltd,located in Zhejiang Province, China,was established in the early 90s.We offer all kinds of water filter cartridges for distributors,dealers and OEMs.Our water filter cartridges include a wide range of multi folding filter cartridges(pool&spa filter cartridge,standard filter cartridge,big blue filter cartridges,Hurricane filter cartridge),activated carbon filter cartridge,PP Melt blown filter cartridge,string wound filter cartridge,capsule filter cartridge,PP micro pleated filter cartridge,membrane pleated filter cartridges,resin impregnated cellulose filter cartridge,and some other swimming pool supplies.

20) Development Center of Water Treatment Technology, SOA, Hangzhou

http://www.chinawatertech.com/index_ch.asp

Microfiltration, ultrafiltration, nanofiltration, reverse osmosis

21) Dow Chemical (China) Investment Company LTD - Shangai

www.dow.com

FILMTECH reverse osmosis membranes, DOWEX ion exchange resins to meet global needs for water treatment, as well as specialized applications in industries including pharmaceuticals, fine chemicals, chemical processing, beverage and dairy processing etc.

22) Eastern Pure Industrial Co., Ltd.

Address: 6f Lane 454, Chung Cheng Rd., Yunho, Taiwan, China

City/Town: Yunho

Province/State: Taiwan

Country/Region: China

Postal Code: 234

This company manufactures different models of water filter unit in Taiwan. Its products including domestic R.O. systems, water purifiers, filter housings, filter cartridges, components and

accessories all with very nice quality. Their products sell to many countries such as: USA, South America, Europe, Asia, India, Pakistan, Middle East, New Zealand and wins good response from our customers.

Production: R.O. Membrane

Description: Organic thin film,50 GPD

23) GE Osmonics Inc.

Post Code: 100004

Tel: +86-10-85261281/85261282/65260848

Fax: +86-10-85261283

E-mail: osmobj@public3.bta.net.cn

<http://www.gewater.com>

Osmonics Inc. was acquired by GE company in Novembre 2002.

From one end of the filtration spectrum to the other, GE Osmonics has a total commitment to fluid purity. GE Osmonics focuses on five worldwide markets: Power and Industrial Processing, Potable Water, Health Care / Pharmaceutical, Food Electronics Manufacturing. It provides standard machines, components and filtration products to fit many applications through local distributors and system integrators.

24) GE China (General Electric Company)

<http://www.ge-china.com/>

25) Guangzhou Asian Tec Water Treatment Limited

<http://www.asiantec-water.com/doce/pf.htm>

Asian Tec Limited and its subsidiaries are an international group of companies. The subsidiaries comprises Guangzhou Asian Tec Water Treatment Limited, The company has the most advanced water treatment technology and equipment. With a group of experienced technical engineers and its advanced water treatment technology and commercial application, Asian Tech. Limited offers engineering products and systems group which have been recommended by the line experts. The company has been awarded the Certificate of Membership by Water Quality Association, Permanent Member Enterprise of China Membrane Industry Association, Member of China Waste Water Recycle Association. The company pioneers in the development and application in reverse

osmosis technology and membrane technology like ultrafiltration and has a renowned reputation in the industrial water treatment.

With the most advanced water treatment technology in the world and the process design suitable to the China practical situation, the company specialized in designing, producing, installing and adjusting the industrial water purification & treatment system, waste water recycle system, sea water desalting system, ultra-pure water treatment system, before and after pretreatment system, de-ion water treatment system and other water, waste water treatment system, which are widely used in various industries including power, electron, metallurgy, chemical, pharmaceutical, food and beverage.

The wholly owned Guangzhou Asian Tech. Water Treatment Limited has powerful technical people, advanced equipment and abundant storage, can provide a wide range of full line of system or components for various types of business and industries.

For the convenience of the users, our service network covers Hong Kong, Guangzhou, Beijing, Shanghai, Jinan, Xian, Yinchuan etc. Welcome your inquiry at any moment and we'll provide you fast and complete before and after sale service sincerely.

26) Guangzhou Great Water Tech. Co., Ltd.

Address: No 783, Xiagang Road, Guangzhou Economic&Technological Development zone, Guangzhou, China

Tel: +86-411-82088668

www.greatwater.com.cn

Process:

- RO

Products:

- Manufacturer of membrane and module
 - Membrane material: PP, CA
 - Module type: hollow fiber
 - Module dimension: $\Phi 90 \times 500$, $\Phi 90 \times 100$, $\Phi 65 \times 250$

27) Hainan LiSheng Technology Ltd

Address : 63 Chenglinzhuang Road .Hedong District. Tianjin.China

Postcode: 610031

Tel: 86 028 86240955

Fax: 86 028 8625021

<http://litree.fatten.net>

28) Hangzhou Anow Water Treatment Co.,Ltd

Address: Room 903 ,Central Building, 271# hushu south road, Hangzhou, China

Post code: 310005

Tel: +86-571-28820198 28820957

Fax : +86-571-28820197 28820955

E-mail: anow@anow.com.cn

Sales E-mail: sales@anow.com.cn

www.anow.com.cn

Hongkong Tel : 00852-21230200

Hongkong Fax : 00852-21211095

Hangzhou Anow Water Treatment Co., Ltd is a Sino-American joint venture and a hi-tech enterprise which is specially engaged in studying and producing pleated cartridge type filter core with spectrum precision and micropore membrane for 15 years.

The company owns the environment of production and hygiene being in conformity with the international standards, adopts internationally advanced workmanship for filter core and the monitoring measures for quality. Daily output has been reached to 5000 pieces of N6, N66, CN-CA, PVDF, PTFE, PES, ACF, PP (0.05 μ m~5 μ m) pleated cartridge type filter core with spectrum precision and 3000 M² N6, N66, CN-CA, PVDF, PTFE (0.05 μ m~5 μ m) micropore membrane by 10 sets auto production line and monitoring measures.

The company has varieties of filter materials (such as, nylon, mixed fibre, polysulfone, fluorine materials and polypropylene etc materials), micropore membrane and pleated cartridge type filter core with spectrum precision and related corollary equipment. The company's products and techniques have been extensively applied to pharmacy, microelectronics, water treatment, food and beverage, biological engineering and laboratory etc. fields.

Anow Company will solve the problems on filter for you wholeheartedly. Their specialized products and services will make your filter system to be in the optimum application state.

The filter core made by the company adopts the pleated type filter layer with great filter area and imported supporting layer for deflector provides the optimum protection without impurities coming-off.

The various sealing parts for the filter core are produced by the imported equipment of automatic sweat soldering without bonding, and have stable and reliable quality.

29) Hangzhou Big Dipper membrane products Co., Ltd

Address : 50 Wenyi Road west, Hangzhou, ZheJiang, China

Postcode: 310012

Tel : 0571-88935351 88935382

Fax : 0571-88935429

Email : www.bdxm.com

30) Hangzhou MEY Water Treatment Co., Ltd.

Post Code: 311404

Tel: +86-571-63257701/85270498

Fax: +86-571-63257701

E-mail: feng@meywater.com.

Main products:

- Membrane housing: spiral membrane housing, hollow fiber membrane housing, ceramic membrane housing
- FRP Pressure Vessels
- Filter Housing: Cartridge Filter Housing Industrial Bag Housing, Sanitary Filter Housing
- Disc Filtration & System
- MF Membranes
- Hollow Fiber UF Membranes

Application:

- Water treatment: Desalination of sea water , Industrial water, Chemical industry, Drinking water, Electric power, Electronic semiconductor, Softened water in boiler
- Liquid separation concentrate: Pharmaceutical industry, Foodstuff, Industrial water liquid, Electrophoretic paint.

31) Hangzhou Sq Environmental Engineering Co., Ltd.

Post Code: 310003

Tel: +86-571-87290576

Fax: +86-571-87292381

E-mail: Sunyo_hz@yahoo.com.cn

<http://www.sqhz.com>

SQ is pursuing to provide of membrane for water treatment and wastewater reuse. It has research and practice experience in membrane bioreactor and can supply equipment for water treatment and wastewater reuse. Hollow fiber membrane module has series specification, which is used for water purified, pre-treatment for RO, separation and concentration.

32) Hydrochem Engineering (Shangai) Co., Ltd.

Post Code: 201203

Tel: +86-21-50805118

Fax: +86-21-50805132

E-mail: rose_xu@hyflux.com.cn

<http://www.hyflux.com>

This is a high-tech engineering company with special engaging in membrane separation, bioengineering downstream processing and water treatment. The company aims at the global market and provides worldwide various industrial enterprises with the most advanced technology of membrane separation, water treatment and equipment operational management. The company has spread its affairs over the bio-pharmaceutical, food, beverages, chemical fiber and dye, semiconductor, microelectronic, petrochemical and mining industries etc. Hyflux presents total and complete services covering all aspects of consulting, designation, manufacturing, instalment, testing.

33) Hyflux Hualu Membrane Tech. Co., Ltd.

e-mail: hualumec@mail.hz.zj.cn

<http://www.zdkaihua.com>

Current Conditions of the Enterprise: It is the domestic leading manufacture and service provider of hollow fiber membrane materials, apparatus and whole-set equipment of membrane separation, distribution and service on environmental protective membrane materials, apparatus and whole-set equipment for the treatment of municipal and industrial wastes and water reclaiming. Relied on the Macromolecule Science and Material Research Institute of Zhejiang University, the scientific research team of this company, the members of which win academician titles of Chinese Academy of Engineering, carries out the basic research of membrane science. By far, this company has won 16 authorized and published patents. Owing the standard factories of nearly 10,000 square meters, advanced membrane-making technology and production equipment of membrane apparatus, the company set its development objective as to become the international leading manufacturer and service provider of membrane separation environmental protection apparatus and equipment to guide the development of Chinese membrane industry.

34) Huachgfeng Electric Equipment Institute of Technology (HAF)

Separation and Filtration Technology, Vapour Recovery Systems, Coalescer, VOC Recovery, Dehydration, Membranes; Waste Water Treatment - Sludge Handling: Belt Filter Presses, Oil-Water Separators, Centrifuges, Rotary Drum Vacuum Filters, Dewaterers, Digesters; Water Supply & Purification - Water Filtration: Filtration Processes, Filter Media and Elements, Sand Filters, Microstrainers, Carbon Adsorption - Membrane Processes: Reverse Osmosis, Electrodialysis, Ultrafiltration, Nanofiltration; Air Pollution Control - Air Filtration: Fabric Filters, Baghouses,

Ceramic Filters, Cartridge Filters, Filter Media, Activated Carbon, Fume Extraction - Vapour Recovery Processing: VOC Adsorption, Claus Sulphur Recovery Units, Cryogenic Distillation, Regenerative Thermal Oxidizers

Street: 8, Da-Jian Road

District: Fangshan

City: Beijing 102400

Country: China

Tel: (+86) 10 - 8134 8166

Fax: (+86) 10 - 6932 6142

E-mail: china_half@sina.com

Internet: www.china-half.com

Activities: **Separation and Filtration Technology, Vapor Recovery Systems, Coalescer, VOC Recovery, Dehydration, Membranes**

35) IMT B.V.

Address : suite 2404 ,NO.23 ruijin nan yuan ,lane 458,ruijin nan Rd shanghai

Postcode: 200032

Tel : 86 21 64224369

Fax :86 21 64042872

Email :jacksju@126.com

Website : www.imtmembranes.com

IMT ,manufacturers and sales UG and MF membrane elements all over the world.IMT incorporates over 30 years experience in hollow fiber technology with Dr.Dick koenhem,the founder of the first hollow fiber technology ,together with nico Marsman and kees van der geer.

36) inge AG Germany Beijing Representative office

Post Code: 100004

Tel: +86-10-65907839

Fax: +86-10-65907836

E-mail: hu.jianhui@inge.cn

<http://www.inge.ag>

inge AG is an independent manufacturer of membrane technology in the market of drinking water and waste water treatment.

Ultrafiltration is used in high-technology-oriented segments (e.g. aviation and aerospace). Inge AG is in a leading position in the market of ultrafiltration and has set up a serial production of the

patented “Multibore®.” membranes which are assembled into hydrodynamically optimized filtration modules.

37) JilLin City JinSai Technology Development Co., Ltd.

Post Code: 132013

Tel: +86-432-4654228/13596238222

Fax: +86-432-4654228

E-mail: jlsjgs@mail.jl.cn

<http://www.jljgs.86114.cn>

JilLin City JinSai Technology Development Co., Ltd. Was found in Dec. 2000. The company is engaged in science and technology design, product, project install, technology debugging and service. The company is one of the member of MIAC and has the membrane product technology patent. Among them, the project of hollow fiber separate membrane was ratified the state grade new technology project in 2002. Sighting the newest technology for membrane separate, product all kinds of polyether sulfone resource. All kinds of membrane assembly and the suit of membrane machine. At the same time, all kinds of equipment of product water, life water, none bacterium water, all kinds of the subassembly and equipment of Chinese traditional medicine purify and refine, separate, concentrate, and the equipment of filtrating and getting rid of bacterium for beer and wine.

38) Jiangsu Jiuwu High Tech Co., Ltd.

Address: High-tech zone, Nanjing City, 210009, Jiangsu Province, China

Tel: +86-25-58744995/13851633082

Fax: +86-25-58744718

E-mail: customer@jiuwu.com

www.jiuwu.com

As the biggest professional manufacturer of ceramic membrane in China, JIUWU have been devoting to researching/manufacturing/developing ceramic membrane product and applications. Its product ranges from Ceramic Membrane of MF/UF/NF and membrane Modules to Membrane Engineering system in different field.

Process:

- MF Ceramic membrane, UF Ceramic membrane, PV MF Ceramic membrane

Products:

- Ceramic membrane R&D
- Ceramic membrane manufacturer

Membrane material	Membrane bore [nm]	H ₂ O permeability at 20°C [L m ⁻² h ⁻¹ bar ⁻¹]
α-Al ₂ O ₃	800	4000
α-Al ₂ O ₃	200	1200
ZrO ₂	50	450~600
TiO ₂	10	100
γ-Al ₂ O ₃	4	10

- Membrane module and unit supplier

39) KOCH Membrane System Inc.

Post Code: 200122

Tel: +86-21-58407426/58407427

Fax: +86-21-58407752

E-mail: pangr@kochind.com

<http://www.kochmembrane.com> / www.kochind.com

KOCH Membrane System, Inc. is the largest manufacturer of industrial scale ultrafiltration equipment in the world. It is an ISO 9001 certified company. In addition to UF and RO membranes and systems, the company manufactures nanofiltration, microfiltration, and other advanced membrane products in a variety of configurations including hollow fiber, spiral, and tubular shapes. The company sells equipment in a wide variety of markets, such as municipal drinking water, industrial wastewater, juice, dairy, wine, pulp and paper, automotive, pharmaceutical and biotech, sweeteners and to many, many more markets beyond the ones listed.

40) Kunshan Jingchen Membrane Tech. Co., Ltd.

Post Code: 215331

Tel: +86-512-57875628/57677828

Fax: +86-512-57874107

E-mail: pujunfl202@vip.sina.com

Jemandfs.cn.alibaba.com

Main products:

- Membrane and membrane production research, development and design.
- Production of polypropylene hollow fiber membrane.
- Production of hollow fiber membrane modules, filtration system for project.

- Production of membrane bioreactor modules and system.
- Production of UF cartridges.
- Production of household/commercial UF equipment, household purifier, integrated drinking machine, pipe style drinking machine.
- Production of 10'', 20'' housings, 50G RO shell, JOCO fittings, wrench.
- All kinds of cartridges, such as sediment, carbon, resin, mineral, etc.
- All kinds of purified water machine for industry or experiment.
- Water treatment for drinking and food industry.
- Treatment of living wastewater, medium water, industry wastewater.

Separation or concentration for food and pharmaceutical industry.

41) Litree Company

Post Code: 518040

Tel: +86-755-83849777-135

Fax: +86-755-83849420

E-mail: market@litree.com

www.litree.com

LITREE COMPANY is a high & new-tech enterprise mainly concentrated on research, development and manufacture of ultra-filtration membrane. LITREE Purifying Ultra-filter achieves international advanced standard, whose core is hollow capillary ultra-filtration membrane, which is resistant to pressure, friction, dirty and erode; and its initiated cross flow, resolves block by dirty radically which common filter hardly overcomes, so that increases flow rate and longevity vastly. LITREE products include house hold purifying ultra-filter, ultra-filtration membrane module for industry and purifying systems for office.

Process:

- UF

Products:

- Manufacturer of membrane and module
 - membrane material: modified hydrophilic PVC
 - module type: hollow fiber
 - module dimension: 1358×Ø143 mm, 1398.5×Ø187 mm, 1713.5×Ø277 mm

42) MEMBRANA

Address : 13800 south lakes Dr.

Postcode: 28273

Tel : 011 587 8888

Fax : 011 587 8410

Email :info@liqui-cel.com

Website : www.liqui-cel.com

Liquid-cel Membrane contactors have been used for more than 15 years to remove gases from liquids. O₂ removal to 1ppb and CO₂ removal to 1ppm in the semiconductor, power, pharmaceutical, medical/analytical, beverage, photographic, digital printing and other industries are common applications.

43) MEMCOR AUSTRALIA PTY. LTD.

Post Code: 200001

Tel: +86-21-63525797 +86 13003192922

Fax: +86-21-63525753

E-mail: Johnny.zheng@usfilter.cn

<http://www.usfilter.com>

Memcor is the Australian based company that pioneered the use of large scale membrane technology for municipal water and wastewater filtration.

Memcor develops low-pressure hollow fiber membrane technology for both drinking water and wastewater treatment, providing services to municipal, industrial, commercial and institutional customers.

Products and/or Services: Hollow fibre Membrane Microfiltration (MF) systems in polypropylene (PP) and PVDF membrane fibre to process surface waters, industrial wastewater, brackish water, seawater and municipal wastewater.

Systems include:

AXIM: Compact low cost, low pressure membrane filtration (CMF-L) skid units for industrial, commercial and municipal water treatment from river water.

AXIA: Memcor's® Submerged Continuous Micro-Filtration (CMF-S) process on skid units low in capital and operational costs.

CUSTOM: Custom designed submerged systems for larger flow membrane filtration systems for water and wastewater treatment, RO pre-treatment and industrial applications.

MBR: Membrane Bioreactor technology (MBR) for wastewater treatment and reuse.

44) MemSet Technologies LLC, USA

Address : 11-12 zhangguiqiao RdW, wanan RdW shanghai.

Postcode: 200434

Tel : 86 21 51089982

Fax : 86 21 51089982-106

Email :info@mstmembrance.com

MST specializes in UF hollow Fiber membranes for applications in industrial, municipal drinking water, wastewater recovery, desalination, and UF spirals for E-Coating.

45) Mega Vision Membrane Engineering & Technology Co., Ltd.

<http://www.lanjinggroup.com>

Tel: +86-10-64803023

Beijing MegaVision Membrane Engineering & Technology Co., Ltd.

Tel: +86-21-50907680

Shanghai MegaVision Membrane & Technology Co., Ltd.

Process: PV and VP.

Products:

- modified PVA/PAN composite membrane series (MPV9801, MPV9803, MPV9804, MPV0201, MPV0202) which permeate water preferentially
- membrane module and unit:

Module Type (Plate and frame)	Dimension [mm]	Membrane area [m ²]
MPD-S	500×250	8~10
MPD-I	500×275	10~25
MPD-II	500×500	25~50
MPD-III	1000×500	50~75

Shanghai Megavision Membrane Technology & Engineering Co. Ltd. (**MVS**) is a young and energetic membrane technology company, which is in close collaboration with the Chemical Engineering Department of Tsinghua University (No. 1 Engineering University in China). The Pervaporation Membrane technology being offered by MVS is based on years of research work done by the University. MVS is the commercialization and marketing arm of the University for their proprietary membranes for various Pervaporation and Ultra-filtration process applications. It has got two production lines for Pervaporation Membrane production and one production line for Ultra-Filtration production. MVS is the leading membrane manufacturing and application Development Company and the only commercial Pervaporation Membrane producer in China. MVS is the only company, who has commercialized the Pervaporation Technology for Isopropanol Dehydration, Isobutanol Dehydration and Benzene Dehydration processes based on their own polymer based pervaporation membrane.

46) Nanjing Jiusi High-Tech Co., Ltd.

www.Jiusi.com

Tel: +86-25-83319580

Fax: +86-25-83300345

Address: Nanjing City, 210009, Jiangsu Province, China

Process:

- MF Ceramic membrane, UF Ceramic membrane, PV MF Ceramic membrane

Products:

- Membrane module and unit supplier, process solution, engineering

47) Nanjing Kaimi Technology

Address: 13-D, HuangPu Building, No 2 HuangPu Road, Nanjing 210016, China

Tel: +86-25-84815076

www.kaimitech.com

Process:

- UF, RO, NF

Products:

- Be the agent and OEM of American Koch Membrane System, Inc.
 - Module type: spiral-wound, tube, hollow fiber, ceramics

48) Nittodenko/Hydranautics

Post Code: 100022

Tel: +86-10-85803253

Fax: +86-10-85801253

E-mail: hybeijing@hydranautics.cn

<http://www.membranes.com>

Hydranautics is now one of the most respected and experienced firms in the membrane separation industry and was acquired in 1987 by the Nitto Denko Corporation. Hydranautics is the first membrane manufacturer to meet the highest quality standards with ISO 9001 Quality System Certification and produces the most innovative and effective membrane products for the water treatment industry.

49) NORIT

Post Code: 100004

Tel: +86-10-64366718/7/6

Fax: +86-10-64366719

E-mail: molemarket@xflow.nl

<http://www.x-flow.com>

The NORIT Group includes the following members under the NORIT Water and NORIT Beverages Divisions: Norit Membrane Technology (NMT); X-Flow membrane products; Norit Process Technology (NPT); Sudmo Components; Haffmans.

It supplies capillary, hollow fiber and tubular membrane products for Micro, Ultra, Nano, and RO filtration. It provides membrane technology used in industrial process water, drinking water, wastewater reuse and reclamation, leachate etc. and membrane treatment systems used in liquid food, beverages, beer and wine, dairy, and pharmaceutical industry.

50) Nutrend Chemical and Electronic Tech Devel Co., Ltd.

Nutrend technology developing chemistry & electronic engineer co. ltd is one of the members of The Membrane Industry Association of China. Since our establishment in 1992, we have devoted ourselves to development and manufacture of products of liquid/air and gas purification.

51) Omexell, Inc.

Adress: Rm. 2906, China Life Building, No. 166, Lujiazui Road (E), Pudong New area, Shanghai, China

Zip : 200120

Tel: (021) 6841 9109

Fax: (021) 6841 9309

E-mail: info-china@omexell.com

Omexell Inc. (a Texas Corporation) is headquartered in Houston, TX, USA. Their specialties include research & development, design, engineering, manufacturing, installation, and service of Integrated Membrane Technology (IMT) equipment used in the process of water treatment. Omexell™ is proudly certified as compliant to ISO 9001, an internationally recognized and accepted quality standard. Their primary systems manufacturing is done in a custom built 90,000 ft² (8,500 m²) facility. Their complex also has a 50,000 ft² (4,700 m²) membrane manufacturing center, and a 60,000 ft² (5,600 m²) membrane R&D center complete with the latest technology in testing and analytical equipment. Integrated Membrane Technology or IMT, consists of three major

membrane based water treatment components: UF (ultrafiltration), RO (reverse osmosis), and EDI (electrodeionization). UF, in most cases, is replacing microfiltration (MF) due its comparable flux and ability to remove particulates that are an order of magnitude smaller. Similarly, today's RO membranes can bypass the need for nanofiltration (NF) leaving the three major membrane technologies of UF-RO-EDI to achieve high-purity water requirements. Omexell has been developing membrane technologies since 1998 and has now emerged as a leader in IMT with its patented spiral wound EDI and unique hollow fiber UF technologies. Industry proven Omexell UF and EDI systems together with RO make IMT a cost-effective alternative for total high-purity water treatment. There are many equipment options and configurations that these systems can be used in to provide specific water purification objectives. UF-RO-EDI systems can be used in tandem for complete water treatment applications, independently for specialized applications, or in paired configurations such as UF-RO and RO-EDI for alternate water treatment requirements. Consult with our expert staff to find the correct application for your water purification requirements.

52) Quanzhou source membrane science&technology development co.,ltd

Address : B204,No.51,incubation base national high-tech enterprises,detai road,quanzhou economic&technology development zone,fujian,China

Postcode: 362005

Tel : 86 595 22497007

Fax :86 595 22496007

Email :wuteshu@21cn.com

Suoai corporation is a technological enterprise that integrates the research,development,production,application and promotion,consulation and after services of membrane separation technology which is listed among the top six high and new technologies nowadays.

53) SAEHAN Industries Inc.

Post Code: 100028

Tel: +86-10-64678387/64678389

Fax: +86-10-64635657

E-mail: weiliang@saehan.co.kr

<http://www.saehancsm.com> / www.saehan.com.cn

Saehan Industries is a giant multinational company which covers all kinds of area and industries, mainly including textile, water treatment equipment, purifier, RO membranes, etc...This is one of the quite few high technology company that can self-develop and manufacture industrial RO membrane.

54) Shandong Tianwei Membrane Technology., Ltd.

Postal Code: 261061

Tel: +086-536-8867639

Fax: 13963631139

E-mail: info@tw-membrane.com

<http://www.tw-membranr.com>

55) ShanDong Zhaoyuan Zhaoyuan Motian Group

Address: No 132 Rd.wenquan Zhaoyuan City 265400, Shandong Province, China

Tel: +86-535-8113296

www.chinamotian.com

Process:

- UF, MBR, RO, MF

Products:

- Manufacturer of membrane and module
 - UF: hollow fiber
 - RO: spiral-wound

56) Shanghai Lanjing Membrane Tecnology Company

Tel.: 021 50907680

Fax: 021 50907681

E-mail: pu@lanjinggroup.com

lanjing@lanjinggroup.com

This company has diversified business mainly related with chemical, petrochemical and environmental industry. One of core business is the [membrane](#) technology. It has the advanced technology to produce the [Pervaporation](#) membrane and [Ultrafiltration](#) membrane for separation process and water treatment process.

57) Shanghai MegaVision Membrane and Technology Co Ltd

Street: 1989 Weiqing Road

District: Jinshan Zui Industrial Zone

City: Shanghai 201508

Country: China

Tel: (+86) 21 - 6854 0166

Fax: (+86) 21 - 6854 8978

E-mail: twq@lanjinggroup.com

Internet: www.lanjinggroup.com

Activities: **UF Hollow Fiber and Pervaporation Membrane Producer**

58) Shangai Yiming Filtration Technology Co., Ltd.

Address: No. 1719, JiaLuo Road, JiaDing District, ShangHai, 201800, China

Tel: +86-21-59556466

Fax: +86-21-59553216

E-mail: office@yimingfilter.com.cn

www.yimingfilter.com.cn

The company is a permanent member of Chinese membrane industry association, the head compiling unit of industry standard of microporous membrane and its filter, micro filter products inspection center, evaluated as national enterprise with good quality and good variety of membrane products by China technology supervision information association. The company products have been used every industry field extensively.

Process:

- MF, UF, ED, RO

Products:

- Membrane equipment supplier, process solution, engineering

59) Shanghai xinchen water treatment co.,ltd

Address : 302 NO.46 lane 460 hongzhong Rd.minhang zone shanghai

Postcode: 201103

Tel : 86 21 64064716 64064717

Fax :86 21 64064718

Email : zhangjw@xcwt.com.cn

Website : www.xcwt.com.cn

60) Shenzhen Sky Forest Enterprises Co., Ltd.

Shenzhen Sky Forest Enterprises Co., Ltd. Is an all-around trade company. Sky Forest is the license distributor of Hydranautics' membrane products. Sky Forest has built the largest network of membrane products.

61) Shenzhen Become Industry & Trade Co., Ltd.

Address: Room 411 Jiazhaoye Commerce Bldg, No. 7 Cuizhu Road, Luohu Dist., Shenzhen, Guangdong, China

City: Shenzhen

Province/State: Guangdong

Country: China

Postal Code: 518020

Tel: (+86) 755 - 2561 6162

Fax: (+86) 755 - 2553 8862

E-mail: chord-88@vip.163.com

Internet: www.root86.com

Activities: Developing and Exporting Filter Medium and Products for Activating, Purifying and Mineralizing Water and Air

It is specialized in development and exporting of the following nine series products:

1. [Tourmaline Ceramic Ball](#) For Activating, Purifying Mineralizing Water
2. [Living Water Filter](#) For Household, Office, School, Hotel, Health Care Beauty Parlor
3. [Water Filter Cup, Water Filter Kettle](#) For Household, Office, Trip and Field
4. [Air Cleaner Medium, Photocatalyst](#) For Air and Water Purification, Pigment, Ceramic and Plastic Industry (No need of electricity)
5. [Air Purifiers](#) For Indoor, Car, Computer and Trip (Need of electricity)
6. [Energy Care Socks, Sports Sleeve Guards, Health Eye Mask](#)
7. [Negative Ion Powder](#) For Activated Water, Paint, Health Care Plastic
8. [Nanofiltration Membranes, Nanofiltration Filter](#) For Water Purifier, Cup Jug Filter, Commercial Filter Equipments
9. [Microbial Sewage Treatment](#) For Sewage Wastewater Treatment

62) Siemens Ltd.,China

Address : 7,wangjing zhonghuannan lu ,chaoyang district,Beijing

Postcode: 100102

Tel : 86 10 64766278

Fax :86 10 64764715

Website : www.seiemens.com/water

Siemens offers the broadest range of products,systems,solutions and services.

Siemens water technologied delivers cost-effective and reliable water and wastewater treatment system and services to municipal,industrial,commercial and institutional customers worldwide.

63) Sino-Filter Co Ltd

Street: 879-3 Zhong Jiang Road #B313

District: Putuo

City: Shanghai 200333

Country: [China](#)

Tel: (+86) 21 - 5109 9372

Fax: (+86) 21 - 5101 0572

E-mail: sino-filter@163.com

Internet: www.sino-filter.com

Activities: **Water Purification Equipment and Accessories Manufacturer for Residential and Industrial Use, incl. Cartridges, RO**

64) Sino-French Dougguan New Era Microfiltration Equipment Co., Ltd.

Tel: +86-769-5525350/5520937

Fax: +86-769-5524778

E-mail: dgnem@dgnem.com

<http://www.dgnem.com>

DGNEM is one of the leading companies in membrane filtration and innovated water and wastewater treatment technology in China, which provides R&D of membrane water treatment technique, process design, equipment manufacturing, installation & commissioning and after-sale services.

Aquasource

Aquasource is the French leader of ultrafiltration for water treatment: from membranes manufacturing to units installation on site. Aquasource technology adapts to the clarification/disinfection of drinking water and to the various industrial applications.

65) SINO-U.S Cooperation Hebei R.O Environmental Tech., Inc.

Post Code: 052165

Tel: +86-311-3090005

Fax: +86-311-3090008

E-mail: sjzro@163.com

<http://www.sjzro.com>

This factory is the only industrial production base which produces spiral Reverse Osmosis element, NF element, Ultra-Filtration element and purification water system.

66) Suntar Membrane Technology (Xiamen) Co Ltd

Building: Suntar Technological Park

Street: Zhongya Industry City

District: Xinglin

City: Xiamen 361022

Country: [China](#)

Tel: (+86) 592 - 677 81 20

Fax: (+86) 592 - 677 82 00

E-mail: info@suntar.com

Internet: www.sinomem.com

Activities: **Provide Membrane-based Process and Engineering Solutions for Separation, Purification and Clean Production**

67) Tianbang National Engineering Research Center of Membrane Technology Co., LTD.

Address: 457 Zhongshan Rd. Dalian, 116023 P.R.China

Tel.: +86 411 4379181

Fax: +86 411 4677947

www.permtech.com.cn

This company manufactures systems for hydrogen recovery, natural gas purification and nitrogen – oxygen separation. It also develops and realizes systems for Microfiltration, Nanofiltration, Ultrafiltration in pharmaceutical and chemical plants; for reverse osmosis seawater desalination.

Process:

- Gas membrane separation including H₂ recovery, O₂ enrichment, N₂ enrichment, VOC's separation

- Liquid membrane separation including medical pure water preparation, pyrogen removal, reused-water, NF, RO

Products:

- Membrane manufacturer, membrane separator and unit supplier

- H₂/N₂ separation:

membrane material: polysulfone

module type: hollow fiber

module size: Φ50×3000, Φ100×3000, Φ200×3000

- O₂/N₂ separation:

membrane material: silicone rubber/PSF

module type: spiral-wounded

module size: Φ100×1000, Φ200×1000

O₂ concentration: 28~30%

A_{O₂/N₂}: 2.0

68) Tianjin Tiangao International Economic Development Corp.

Company Name: Tianjin Tiangao International Economic Development Corp.

Company Address: 100 Yingshui Road Nankai District Tianjin China

City: Tianjin

Province/State: Tianjin

Country/Region: China

Zip/Postal Code: 300191

It is a company that realizes different products. The main products are as follow:

1. Ozone Air Purifier (OZX-A3500)
2. Ozone Generator (OZX-A500B)
3. Ultra Filter Membrane

69) Tianjin Motimo Membrane Technology Co., Ltd.

Post Code: 300457

Tel: +86-22-66230233

Fax: +86-22-66230131

E-mail: sales@motimo.com

<http://www.motimo.com>

MOTIMO's main products are as follows:

- Hollow fiber MF and hallow fiber UF (material: PVDF, PS, PES, PAN)
- Outside-in and Inside-out membrane modules
- CFM, TWF and other membrane modules
- FP membrane modules for MBR
- MOTIMO's Products are spread all over 31 provinces and some are exported to other countries, such as Singapore, Korea.

Used in the following fields: treatment and recycling of municipal & industrial wastewater; pre-treatment for large scale RO systems; clarification of juice, beverage and wine; supply purification water without bacteria; separation textile wastewater and latex; concentrating removing or separating in bio-pharmaceutical industries.

70) Tianjin Novo Fangyuan Membrane Separation Technology Co., Ltd

Post Code: 300190

Tel: +86-22-87613348/87613899/87613345/87613346

Fax: +86-22-87613833/27032399

<http://www.novofangyuan.com/www.novospring.com/www.tjfangyuan.cn>

Tianjin Novo-Fangyuan Membrane Separation Technology Co., Ltd is a 100% subsidiary of Novo Spring International Pte Ltd whose shareholder is PSB, a Singapore governmental company. It is the production base and marketing centre in China of Novo Spring International Pte Ltd. The R & D center and Overseas Sales Department are set up in Novo Spring International Pte. Ltd in Singapore. Novo Spring International Pte. Ltd is engaged in the R&D, designing, manufacturing, sales and services of hollow fiber membrane module. The company is providing high quality products and services and technological support in China and Southeast Asia. The products are widely used in water treatment and wastewater recycling.

Hollow fiber Ultra-filtration Membrane products are divided into three series: modules integrated with plastic casing, SS casing and cartridge-changeable modules and modules integrated with epoxy glass.

71) Toray Industries (China) Co., Ltd

Address: 10th Floor, HSBC TOWER, 101 Yin Cheng East Road, Pudong New Area, Shanghai, China

Post Code: 200120

Tel: +86-21-6841-1470 / 4632

Fax: +86-21-6841-2454 / 3220

<http://www.toray.co.jp>

Toray Group is the world's leading manufacturer of synthetic materials and products. It develops the world's best performing RO, NF, UF and MF. Toray is one of the leading suppliers of RO and NF elements, and UF and MF modules with a global network of distributors. Brackish water and seawater desalination, ultra pure water production for semiconductor, drinking water production and softening are the major applications. Utilizing its membrane technology, Toray also produces water treatment products, such as tap water purifier, ultra pure water production device, pool water purifier and seawater desalination system.

72) Tianjin Motian Membrane Eng. & Tech. Co., Ltd.

<http://www.tj-motian.com>

e-mail: sales@tj-motian.com

Tianjin Motian Membrane Engineering and Technology Co.Ltd. (TMMETC) is a high-tech enterprise built and invested jointly by China Textile International Group based on the former Motian Company of Membrane Technology and Engineering (MCMTE) of Tianjin Institute of Textile Science and Technology (TITST). Its registered capital is RMB 21,280,000, with building area of more than 10,000 square meters. TMMETC is engaged in the research of membrane technology, the development of membrane engineering, the manufacture of relevant products and equipment. Now, TMMETC is the standing council of China Membrane Industry Association and a member of the standing committee of Industrial Sewage Treatment Commission of China Environmental Protection Industry Association.

TMMETC has a variety of hollow fiber membranes of UF, MF, RO, GS and tubular UF, MF, which are in different materials. They have a complete range of specifications and stable performance, and have been applied extensively in many fields of China and other countries. The bio-UF system manufactured by TMMETC has been widely accepted by units of research and production on blood products and bio-chemistry drug production in which 80% blood product annually consumed in China is produced by this system. Diaphragm pump and cam pump, used in the bio-UF system are patented products in our company.

The complete sets of UF equipment with automatic control panel produced by TMMETC are the super products in China. The above products have been successfully used in the fields of pharmacy, food, enzyme preparation, ferment industry, waste water treatment, electrophoresis paint recovery, pure water production etc. Large scale industrial pure water manufacture system and bottled mineral water or pure water production equipment designed and produced by TMMETC have been used by hundreds of enterprises in China.

73) Tianjin MOTIMO Group

Address : 63 Chenglinzhuang Road .Hedong District. Tianjin.China

Postcode: 300160

Tel: 86-022-24528326/24344802

Fax: 86-022-2452825

Email: sales@tj-motian.com

74) TianJin PolyTechnic University MoTian Group

Address: 63 Chenglinzhuang Road, Hedong District, Tianjin 300160, China

Tel: +86-22-24528326/24344802

www.tj-motian.com

Process:

- UF, MF, RO, MBR

Products:

- Manufacturer of membrane and module
 - Module type: hollow fiber
 - Technology R&D: Continuous Membrane Filtration TWF

75) Tianjin Tianfang Membrane Separation Engineering Company

Address: Building D2, XinMao Science&Technology Park, Tianjin 300384, China

Tel: +86-22-83711313

www.tianfang-memb.com

Process:

- UF, MBR

Products:

- Manufacturer of membrane and module
 - membrane material: PAN, PVDF, PS, MPAN
 - module type: hollow fiber
 - MWCO: 10000~20000, 30000~50000, 100000
 - Module size: Φ90×1260

76) Woongjin chemical co.,ltd

Saehan Industries Inc.

Address : Rm.1E state gate mansion No.1 zuojiazhuang chaoyang district , Beijing

Postcode: 100028

Tel : 86 10 64678387

Fax :86 10 64678389

Website : www.wjchemical.co.kr

Seahan Industries Inc is a giant multinational company ,which was separated from SAMSUNG GROUP. Our R/O membrane has been invented and manufactured since 1989. now our factory becomes the most famous manufacture base with 20 years' efforts.

77) Zhejiang Huzhou Jinshan Membrane Separation Equipment Co., Ltd.

Address: 59 Jinde Road, Jinshan Industry Park, Huzhou City 313002, Zhejiang Province, China

Tel: 0572-3321138 3321551

www.zj-jinfeng.com

Process:

- RO, UF

Products:

- Manufacturer of UF membrane and module
- RO, UF membrane system supplier.

78) Vontron ENVIRO_TECH Co., Ltd.

Post Code: 550018

Tel: +86-851-6270368/6270017

Fax: +86-851-6270137

E-mail: sales@vontron.com

<http://www.vontron.com>

Vontron Enviro-Tech Co., Ltd is the largest manufacturer for RO membrane in China at present (2004), with the annual output of 3.3 million sq.m.

Vontron's main products include various aromatic polyamide composite for reverse-osmosis membrane elements. The greatest characteristic of their products is that after the Ultra-Filtration come out, it is made into lower fouling membrane with high-level technology and steady quality compared to the other similar products. These products are used for removing all kinds of impurities in the desalination process. According to the different salt contents, the membrane elements of Vontron are assigned to ultra-low-pressure (ULP) series and so on. For bad quality of water of original water, Vontron offers Fouling-Resistant (FR) elements series. In addition, Vontron can follow the characteristic of the electric charge in the original water of to develop the membrane elements of special antipollution.

The membrane products and technology of Vontron Enviro-Tech are widely applicable to various industries, such as foodstuff and beverages, medicine and pharmacy, municipal water supply treatment, high purity water for industrial purpose, seawater desalting, extra-pure water for electronic industry, wastewater treatment and recycling, concentration and purification of materials, etc.

79) Vontron membrane technology co.,ltd

Address : south huiton hi-tec. Industrial zone,xintian zhai,guiyang,china

Postcode: 550018

Tel : 86 851 6270368

Fax :86 851 6270017

Email :sales@vontron.com

Website : www.vontron.com

Vontron membrane technology co.,ltd is now the biggest producing base for compound reverse osmosis membrane in China,owning and operating its producing lines in being and guiyang.

Chemical water treatment

Beijing NewTek International Inc.

Postcode: 100085

Tel : 86 10 62974022

Fax :86 10 62974033

Website : www.newtekinternational.com.cn

Beijing NewTek International Inc.(BNTI) is a Sino-America joint venture registered in Beijing Zhong- Guan-Cun Science&Technology Development Zone.It is specialized in providing products and services to reverse osmosis system for various treatment applications.

BWA Water Additives UK LTD.

Address :room 19,26/F,Ascendas Plaza ,3333 tian yao qiao road ,xu jia hui,shanghai 200030

Postcode: 100085

Tel : 86 21 64264633

Fax :86 21 23019975

Website : www.wateradditives.com

BWA Water Additives is exclusively dedicated to the water treatment sector and as a result ,our antiscalant ,corrosion inhibitor and microbiocide technologies and services provide our customers with the essential elements required to meet today's water management challenges.

GE Water &Process Technologies

Postcode: 201315

Tel : 86 21 68182900

Fax :86 21 68182933

Website : www.gewater.com.cn

GE Water &Process Technologies is the largest multi-value producer in market ,which can provide Autotrol,Aquamatic values of high quality and high efficiency.These products can be applied to : multi-media filtration ,activated carbon filtration,soften water,desalting etc.Meanwhile,GEWPT also produces family used RO membrane ,filter and water purification machine,which are widely utilized in household and family.

Paques Environmental Technology (shanghai) Co.,ltd.

No.35 jucheng innovation Park ,lane 3999 xiupu road Kangqiao pudong ,Shanghai

Postcode: 201319

Tel : 86 21 38256088

Fax :86 21 38256066

Email : kai.chi@pagues.com.cn

Yu.shen@pagues.com.cn

Website : www.pagues.com.nl

Shanxi Qianteng Electricity Technology Co.,Ltd

4th floor,3A kaiyuan incubator ,science park of jiao Tong university ,99#,yan xiang road ,xi'an Shanxi ,710054

Tel : 86 29 83396093

Fax :86 29 83396091

Email : qt_vip@126.com

Website : www.qttec.com

Shanxi Qianteng Electricity Technology Co.,Ltd is the unique authorized top attorney dealer and technical service provider in mainland of China.

Shenzhen Jiuda water Treatment Technology Co.,Ltd

Address : room number 1001,hua feng building people housing shennan road,Shenzhen,China.

Postcode: 518009

Tel : 86 755 83904967 83904975

Fax :86 755 83904991

Email :shenzhenjiuda@163.com

Website : www.szjiudaqg.cn.alibaba.com

Shenzhen jiuda is a professional engineering company specializing in the design manufacturing development introduction..installation and maintenance of various kinds of water treatment equipments.

Shenzhen zhongrun water industry Technology Development Co.,Ltd

Address : 6/F ,building zhuyuan,no.5 kehua road,Shenzhen,Guangdong province,P.R.China

Postcode: 518057

Tel : 86 755 26630106

Fax :86 755 86367200

Email : office@zrwater.com

Website : www.zrwater.com

Zhongrun water co.,ltd is specialized in the R&D and production of coagulant for water treatment and the related testing instrument.It's located in the Shenzhen Hi-Tech industrial Park nearby Hongkong.

Nalco

1601 W. Diehl Road

Naperville, IL 60563-1198 U.S.A.

Tel: 1.630.305.1000

Fax: 1.630.305.2900

U.S. Order Management: 1.800.288.0879

Canada Order Management: +1.800.265.5059 (English) , +1.800.265.5977 (French)

During the past century, Nalco Company has grown from a fledgling water treatment business to the leading integrated water treatment and process improvement company in the world. It does this by focusing on our core markets of water treatment and process chemicals and on our corporate strengths - global presence, on-site expertise, and innovative products and services.

Frp Pressure Vessel

Wuxi Rework Fibreglass Reinforced Plastic Co.,Ltd

Postcode: 214217

Tel : 86 510 87856369

Fax :86 510 87855391

Website : www.wxrework.com

Wuxi Rework Fibreglass Reinforced Plastic Co.,Ltd specially engaged in producing and researching FRP pressure vessel used for reverse osmosis device,cooperates with domestic macromolecule compound material institutes and concentrates on researching the advantage of FRP pressure concentrates in both domestic and overseas while absorbing advanced production technology and skill in recent years.After endeavor many years.

Harbin ROPV industry development center

Address :unit 2501,pufa mansion ,209 changjiang street ,nangang district,Harbin,China

Postcode: 150090

Tel : 86 451 82267301

Fax :86 451 82267303

Website : www.ropv.com.cn

Harbin ROPV industry development center is the largest FRP Pressure vessel supplier in China,one of the world's fastest growing markets for membrane-based water treatment.

Dalian yuxing water treatment equipment co.,ltd

Address yiheng mansion 703,eastern of north 3rd ring,chaoyang district,Beijing

PC : 100013

Tel : 86 10 64405928

Fax :86 10 64405956

Email :memshell@menshell.com.cn

Website : www.memshell.com.cn

Dalian yuxing water treatment equipment co.,ltd is a specialized manufacturer of glass-fiber reinforced pressure vessels for water treatment by the film separation method,which was established

in 1998 and now become a high-tech enterprise with the self-operated import&export entitlement and the integration in research&development,production and sale.

Wave cyber co.,ltd

Address : No.218 songhai road ,qingpu industrial zone,shanghai

Postcode: 201703

Tel : 86 21 69758588

Fax :86 21 69758288

Email :Patrick@wave-cyber.com

Website : www.wave-cyber.com

Wave cyber co.,ltd the total investement of which is 5 million USD,is invested by wave limited,a British company ,we adopt the most advanced technology and techniques in the world,imported equipment and new type composite material to make state-of-the –art products.

Beijing Pentair water jieming co.,ltd

Address : shahe industrial zone,changping district,Beijing ,china

Postcode: 102206

Tel : 86 10 80722905

Fax :86 10 80722906

Email :jm@jieming.com

Website : www.jieming.com

Beijing Pentair water jieming co.,ltd is a high-and –new-technological company specialized in manufacturing water treatment equipments,with eight domestic subsidiaries,one professional service company and one overseas office.

Changzhou kangpu FRP pressure vessel co.,ltd

Address : NO.2 wujin da dao,lijia town,wujin area,changzhou city ,jiangsu province,china

Postcode: 213176

Tel : 86 519 86233218

Fax :86 519 86233289

Email :kangpuvessel@126.com

Website : www.kangpuvessel.com.cn

Changzhou kangpu FRP pressure vessel co.,ltd is the professional manufacturer of FRP pressure vessel,which is used for RO system.

Shanghai yaohua FRP Co.,ltd

Postcode: 200002

Tel : 86 21 63391818

Fax :86 21 63392611

Website : www.abm.com.cn

Shanghai yaohua FRP Co.,ltd is playing the leading role in production of FRP sandy pipe with big diameters,pressure storage tanks and fitting as Elbow and Flange. The products are widely used in sewage,water supply ,oilstorage etc.

Data Logging

Air power master international corp

Address : 1F,NO.39 ,fu an 10st.,shi-tun dist,taichung

Postcode: 407

Tel : 86 4 23597300

Fax :86 4 23597305

Website : www.airpower.com.tw

Air power master established in 1992,we helps customers to solve difficult manufacturing problems,increase productivity ,improve quality ,and reduce costs. Its profound experience in this market and the support of its customer has enabled it to become one of the leading liquid filtration equipment manufacturers in Taiwan China.

Aqua best technology limited

Address : room 102 ,NO.10 lane 175.hong song road ,minhang district,shanghai,China

Postcode: 201103

Tel : 86 21 54760939

Fax :86 21 54760579

Email : service@aquabest.net

Website : www.aquabest.net

Aqua best technology limited was established in 1991 with offering wide range of products related to residential,commercial and industrial applications.As an enterprise concerned with active healthcare,it committed to the chemical-free treatment of water with UV Disinfection. It began in Shanghai , China, as a manufacturer of Aqua Best ultraviolet sterilizer systems.

BAB-I Co.,Ltd

Address : A7,tianzhu west road,area A,tianzhu airport industrial zone,Beijing ,101300,P.R.China

Postcode: 101300

Tel : 86 10 80487811

Fax :86 10 80493721

Website : www.bab-i.com

BABI was founded in 1992 and headquarters locates in Beijing,China.BABI is established as a knowledgeable and reliable manufacturer in field of instruments and meters for automation.BABI staff pays their efforts to research&develop,produce,manufacture,market and apply process control instrumentations and thermal-laboratory calibration instrumentations.

Bright time technologies(Beijing) Co.,Ltd

Postcode: 100013

Tel : 86 10 84287390 84287600

Fax :86 10 84288652

Website : www.bttol.com

BTT:Your excellent supplier for fluid measurement and control products

BTT is a China-American cooperated high –tech company. We have rich experience and praisable achievements in the field of water analytical instrumentation and process instrumentation.we are key distributors of the following golobal corporations :

HACH,GF SIGNET,FLOWLINE

Danfoss Ro solutions

Address :nordborgvej 81,D25,denmark

Postcode: 6430 NORDBORG

Tel : 45 7488 1622

Fax :45 7445 3831

Email : waterpumps@danfoss.com

Website : www.ro-solutions.com

Foshan aquast electronic aqqliance Co.,Ltd

Address :3rd/F,76 xinning road ,daliang,shunde,Guangdong province

Postcode: 528300

Tel : 86 757 22269296

Fax :86 757 22250807

Email : zd393@yahoo.com.cn

Website : www.aquast.com

Self-designing and production of industrial conductivity instruments.

Pen-type conductivity instruments.

Pen-type TDS instruments.

Ball float level swiches.

Halma water management

Address :ty coch house,llantarnam park way,cwmbran NP44 3AW

Tel : 44 1633 489479

Fax :44 1633 877857

Email : sales@hwm-water.com

Website : www.hwn-water.com

HWM distributor in China name : Allied power technology ltd

Tel : 86 010 51581977

Fax :86 010 51582193
Email : info@aohuacn.com

Website : www.alliedpower.com.hk

Halma water management represents Palmer Environmental Ltd, Radcom Technology Ltd and Hydreka SA manufacturers of flow and pressure loggers, leak detection and pressure management equipment.

Hebei create instrumentation technologies co.,ltd

Address :B3-3-2302,kai yuan hua yuan,xian tian xia,NO>58 yucai street,shijiazhuang ,hebei,China

Tel : 86 311 85696388 85696198

Fax :86 311 85696399 812

Email : webmaster@createc.cn

Website : www.createc.cn

Hebei create instrumentation technologies co.,ltd is a professional developer and manufacturer of industrial on-line instruments,since 1988. It has substantial market share in China. Their instruments are popular, not only in China,but also in international market.

MMP Filtration Pvt Ltd

Address :ty coch house,llantarnam park way,cwmbran NP44 3AW

Tel : 44 1633 489479

Fax :44 1633 877857

Email : sales@hwm-water.com

Website : www.hwn-water.com

MMP Filtration Pvt Ltd is an Indian based company focused in the field of filtration and pollution control. with an experience of over 12 years,MMP is an established brand in the manufacturing and supply of components for Reverse osmosis and other water treatment technology.

ODI Technology Instrument Co.,Ltd

Address :jinxiu road management area cuntou humen town dongguan city ,Guangdong province

PC : 523925

Tel : 86 769 85155601

Fax :86 769 85155029

Email : jinzhiying2008@126.com

Website : www.oditech.com.cn

Company introduction : ODI Technology Instrument Co.,Ltd specializes at producing chemical analysis instruments. It's products sell to international market and have five series including more than ten different kinds.It is ready to provide perfect service and excellent products in domestic and overseas water industry.

Palintest Ltd

Address :Room 1601,kuntai international mansion building 1, NO>B12 chao wai street,chao yang district,Beijing,China

PC : 100020

Tel : 86 10 51261868

Fax :86 10 82626620

Email : fred.fan@palintest.com

Website : www.palintest.com

Palintest ,founded in Newcastle upon Tyne UK 130 years ago,is a world-leading manufacturer of water testing and environmental products for water quality,drinking water,swimming pool and soil element testing.

Savant Electronics Inc

Address :188-2,sec.2, changping road,taichung

PC : 40679

Tel : 886 4 24213758

Fax :886 4 24213710

Website : www.digisavant.com

Manufacturer of water treatment system and test equipment for water.

Digital water filter, Alkaline water filter,digital flow meter,flow sensor,water quality tester.

Shanghai chengci electron co.,ltd

Address :floor 1,NO.22,515 tacheng road.,jiading district,shanghai 201800

PC : 201800

Tel : 86 21 69985760

Fax :86 21 69985096

Email : webmaster@126.com

Website : www.shonest.com

Shanghai chengci electron co.,ltd provides an integrated system of R&D,manufacturing and service for the online conductivity meter,PH meter and flow analyzer.Referring to the advanced technology and experience from the domestic and overseas market.

Shenzhen OMAL liquid Control Equipment Ltd

PC : 518031

Tel : 86 755 83325991 83325992

Fax :86 755 83326630

Email : info@auto-work.com

Website : www.omal.com.cn www.auto=work.com

In 1981 ,in the industrious area of Val Trompia,Omali was founded,the result of previous entrepreneurial experiences of the Bonomi family. On the outskirts of Brescia the pneumatic

actuator was designed and produced of a series of products which today complete the range in industrial components and automation: both electric and pneumatic.

Yuyao NO.4 Instrument Factory

Address : NO.66 changxi road ,yuyao city,zhejiang

PC : 315400

Tel : 86 574 62811732 62811741

Fax : 86 574 62811735

Email : sales@diancifa.com.cn sale@fluid-valve.com

Website : www.diancifa.com.cn www.fluid-valve.com

Yuyao NO.4 Instrument Factory is a professional solenoid valves manufacturer.

Yuyao kingtai instrument co.,ltd

Address : 63# jinchang road ,yuyao,zhejiang,china

PC : 315400

Tel : 86 574 22666333

Fax : 86 574 62648222

Email : kingtai@mail.nbptt.zj.cn

Website : www.zyia.com www.kingtai.en.alibaba.com

Founded in 1989, Yuyao kingtai instrument co.,ltd is specialized in the research and development,manufactures,sales,and services of industry instruments. Their major products are flowmeter,pressure gauge and solenoid valve. It is one of the biggest manufacturer of acrylic flowmeter in China.

Hach Company

P.O. Box 389,Loveland, Colorado, 80539-0389

Phone: 800-227-4224

Fax: 970-669-2932

Engineering Company

Shanghai hantech Co.,Ltd

Address : No.388 xianju road zhujing jinshan shanghai

Postcode:201500

Tel : 86 21 52271100

Fax : 86 21 52271178

Email : steve.liang@hantech.com.cn

Website : www.hantech.com.cn

Shanghai hantech Co.,Ltd was established in 1988 which is invested by Taiwanese company.The head office is shanghai city ,and it has already set up more than ten branch office and warehouse in

china. With over ten years experience, SHANHAI HANTECH CO. has become an integrated water treatment company which has manufacturer, R&D, distribution channel, pre and after service.

Guangzhou crystalline resource desalination of seawater and water treatment co.,ltd

Address : in Guangzhou huang pu area country sea bureau south China aea sub-bureau ship repair yard

Postcode: 510715

Tel : 86 20 82206307 82500408 82501317

Fax : 86 20 82206307 82500408

Email : jywp@china-jywp.com

Website : www.china-jywp.com

Guangzhou crystalline resource desalination of seawater and water treatment co.,ltd ,an ISO 9001:20000 approved company, is the member of the IDA and the member of the Membrane industry association of China, a leading manufacturer of electrodeionization module and EDI equipment in China.

Hyflux Group (Singapore)

Address : 99 juli road, zhangjiang high-tech park pudong area, shanghai

Postcode: 201203

Tel : 86 21 50805118

Fax : 86 21 50805128

Email : yilian_liui@hyflux.com

Website : www.hyflux.com

Hyflux Group is one of the largest water treatment group at the core of the membrane separation technology in Asia-Pacific region, is the chairman of singapore water treatment Association, and is Singapore-listed company, become the largest water supply system vendor and supplied over 35% of the water demand in Singapore.

Degremont technologies (China)

Postcode: 100020

Tel : 86 10 65973860

Fax : 86 10 65973660

Email : info-china@dgtec.com

Website : www.degremont-technologies.com

Degremont technologies: part of Degremont Group, symbolizes the definitive establishment of the equipment branch as one of the degremonts three business, including different equipment-specialized divisions.

ITT (china) investment co.,ltd

Address : room 902-903, E3 building, oriental plaza, No.1 east chang-an avenue, Beijing

Tel : 86 10 85184188

Fax :86 10 85188438

Website : www.itt.com

ITT-engineered for life

ITT corporation is a diversified high-technology engineering and manufacturing company dedicated to creating more livable environments, enabling communications and providing protection and safety.

Stainless Steel Material

H, butting GmbH&Co.KG shanghai Rep.Office

Address :No.199-2,jingxue road,malu town,jiading district,shanghai

Postcode: 201801

Tel : 86 21 69157598

Fax :86 21 69157599

Email : info@butting.com.cm

Website : www.butting.de

For more than 230 years Butting has been supporting the customers with its skill and innovations. It produces longitudinally welded pipes, fittings, piping components and vessels in stainless steels.

Shanghai engineering plastic piping system co.,ltd

Address :2801,buildingE,No.82,caobao road,shanghai

Postcode: 200235

Tel : 86 21 64362111

Fax :86 21 64366111

Email : epp@epp.cn

Website : www.epp.cn

Shanghai engineering plastic piping system co.,ltd is one of the famed professional suppliers specialized in engineering plastic piping system products at home. It offers pipes, connecting fittings, valves made with PVC/CPVC/PP/PVDF and various kinds of other materials.

Shanghai youli water-storing pipes co.,ltd

Address :No.7515 caolang highway,langcia town,jinshan district,shanghai

Postcode: 201516

Tel : 86 21 57394899

Fax :86 21 57392666

Email : youli@youli.com

Website : www.youli.com

Xi'an sunward aerospace material co.,ltd

Composite vessel factory

Postcode: 710025

Tel : 86 29 83607146

Fax :86 29 83606982

Email : sales@htcoma.com

Website : www.htcoma.com www.aeromat.cn

Established in 1999, Xi'an sunward aerospace material co.,ltd .

Composite vessel factory was one of pioneers of fiberglass wound FRP vessel for water treatment . depend on the international leading winding equipment and technology from Aerospace composite material instate. This factory succeeds in developing HTCOMA brand FRP vessels for water treatment.

Wuhu jincheng pipe-fittings co.,ltd

Address :suncun industrial park,fanchang county,wuhu city ,China

Tel : 86 553 7256789

Fax :86 553 7257789

Email : jessie820119@yahoo.cn

Website : www.jmvpt.com

Ductile pipe-fittings,valves,flange adaptor and coupling,manholes and variety os casting such as car fittings.

Outokumpu

Address: HRP-Degerfors

PC: 69381-Degerfors

Tel: +46 586 47626/ +46 70 53 47463

Fax: +46 586 47344

Email: hachemi.loucif@outokumpu.com

Pump

Pentair water

PC : 200092

Tel : 86 21 32114588

Fax :86 21 32114580-83

Email : watertech@gmail.com

Website : www.pentairwater.cn

Pentair is a diversified operating company headquartered in Minnesota. Its water group is a global leader in providing innovative products and systems used worldwide in the

movements,treatment,storage and enjoyment of water. With 2006 revenues of \$3.2 billion,Pentair employs approximately 20,000 people worldwide.

ITT (china) investment co.,ltd

Address :room 902-903,E3 building,oriental plaza,No.1 east chang-an avenue, Beijing

Tel : 86 10 85184188

Fax :86 10 85188438

Website : www.itt.com

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Shanghai flowx value co.,ltd

Address :No.98,lane2501 Dushi road.minhang district shanghai

PC : 200000

Tel : 86 21 54150349

Fax :86 21 54150271

Email :flxvalue@yahoo.com.cn

Website : www.flowxvalue.com

Verder retsch (shanghai)trading co.,ltd

Address :rm 301,tower1,fuhai commercial garden,No.289,bisheng road ,zhangjiang hiteck park,shanghai

PC : 201204

Tel : 86 21 61023700

Fax :86 21 61023711

Email :Helen@verder.cn

Website : www.verder.cn

Verder has proven,for over 45 years,that we are providers of high quality pumping solutions in variety of industries including brewing,water&wastewater treatment ,food and beverage and chemical amongst many others.

Walrus pump co.,ltd

PC :201101

Tel : 86 21 54796690

Fax :86 21 54796695

Website : www.walrus.com.tw

Wuxi jiang da lian sheng water treatment tech Co.,Ltd

Postcode: 214044

Tel : 86 510 83195050

Fax :86 510 82621668

Email : jdls2001@163.com

Website : www.jdls2001.com

Wuxi jiang da lian sheng water treatment tech Co.,Ltd is an industrial high-tech enterprise which is specially engaged in the research,development,design,production and marketing of water treatment equipment and engineering.

Zhejiang cangsong electrical appliances,co.,ltd

Address :lingxi industrial park ,cangnan country ,zhejiang province,china

PC : 325800

Tel : 86 577 68888111

Fax :86 577 64839698

Email :cangsong@yahoo.com.cn

Website : www.cangsong.com

Founded in 1985,covers an area of 13000 sq and constructs an area of 5000 aq.

The company specialized in manufacturing of rotary vane pump. All over properties can be compared to PROCON,Fluid-tech,and achieve the international advanced level.

KSB

The KSB Group is one of the leading producers of pumps, valves and related systems. Annual sales revenue is approximately 1800 million euro.

More than 14,000 employees around the world work for maximum customer satisfaction in building services, industry and water utilities, the energy sector and mining. KSB is increasingly a service partner and provides complete hydraulic systems for water supply and drainage

Sulzer

Corporate Center (Corporation)

Sulzer Ltd

Zürcherstrasse 14

8401 Winterthur, Switzerland

Phone +41 52 262 11 22

Fax +41 52 262 01 01

Website: <http://www.sulzer.com>

Sulzer was founded in 1834 in Winterthur, Switzerland, and is active in over 120 locations worldwide.

Specializing in the manufacturing of industrial machinery and equipment, surfacing technology, and rotating equipment maintenance, the four divisions of Sulzer are global leaders in their respective markets.