

STATUS OF MEMBRANE TECHNOLOGY IN KOREA

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ABSTRACT

Government efforts on membrane technology started in early 1980 with Membrane Development Program supported by the Ministry of Science and Technology. Several independent research projects on liquid separation, pervaporation, gas separation, hollow fiber producing program etc. were carried out during the 1980s. The RaCER was commissioned by MOCI for the general management of the project which had its aims in establishing the base for developing membranes, modules and systems for liquid separation in August 1993. More recently, in June 1995, a program for developing membranes for oxygen separation, nitrogen separation and hydrogen separation was initiated. This paper outlines the brief history of membrane technology development in Korea from the introduction of membrane filtration technology during the late 1960s to present.

INTRODUCTION

The development of membrane technology was among the major areas of interest in the Korean governments' first long term(1992-1996) R&D program for energy conservation technology. Poor in mineral and energy resources, and heavily dependent on atomic energy for power supply, Korea should exert particular efforts on NRSE development and conservation technologies. This stimulates the Korean government (particularly MOCI) to initiate the energy saving membrane technologies program in academia, government and industrial R & D centers starting from the year 1993.

The membrane industries and their market in Korea have been expanded rapidly for the last decades. The market size of membrane modules was estimated to be about US\$ 90 million (1997) excluding hemodialysis modules with the high annual growth rate of more than 20 %. However, the economic crisis caused the decrease of its annual growth of 1998 by 8 %. Major areas of the current membrane market includes production of ultrapure water for semiconductor industries, potable water for home usage and process water. The membrane modules have been imported until quite recently. The large membrane market provoked the membrane R&D as well as the efforts in membrane productions. The membrane R&D has been very active since 1980s and resulted in production of

ultrafiltration and reverse osmosis membranes

HISTORY OF MEMBRANE TECHNOLOGY IN KOREA

In 1960s, microfiltration was first introduced to Korea for membrane filtration and sterilization in the microbiology laboratories and pharmaceutical industries. At the same time, flat sheet membrane hemodialyzer was applied to the medical area for the treatment of kidney patients. In 1974, an electro dialysis plant, the first industrial application of membrane technology was built in Ulsan petrochemical complex to produce annual capacity of 150,000 tons of table salts. In 1985, Monsanto Prism separator for the recovery of hydrogen gas was introduced. However, membrane processes have not drawn general interests from industry until 1987 when a reverse osmosis plant for reverse osmosis plant for the production of process water with a capacity of 10,000 m³/day was built by Kugdong Petroleum Co. Today the production of water by RO over the capacity of 140,000 m³/day is in operation or under construction in Korea. Consumption of ultra pure water is increasing sharply in recent years mainly due to the rapid expansion of semiconductor industry and the introduction of ultra high pressure boilers for power plants. In the meantime, reverse osmosis and ultrafiltration processes were applied to small scale treatment of water, such as, ultra-pure water for laboratories, hospitals and semiconductor plants. In the 1980s, flat membrane hemodialyzer was replaced by hollow fiber membrane module, and bubble-type blood oxygenator was replaced by flat membrane-type. Ultrafiltration was introduced to one of the Kia Motor Co. for treating wastewater from electropainting. The largest plants have been built at the west coast of Korean peninsula for desalination of reclaimed land water with the capacity of 10,000 ton/day and 80,000 ton/day.

As the government regulations on pollution are getting tighter and heading to the total discharge policy instead of present concentration control, membrane processes have been accepted as a major environmentally sound and sustainable technology. A wastewater treatment plant of large industrial scale with a daily capacity of 10,000 m³/day using NF and RO was constructed at Hansol paper manufacturing plant. Posco started a series of 25 million US dollar pilot tests for the installation of membrane processes to treat effluents of wastewater treatment plant for water reuse. Posco plans to increase its budget up to 1 billion US dollar, should the project proves to be successful in the future. Among various membrane related technologies, treatment of leachate from municipal landfill sites is presently attracting particular commercial interests.

MEMBRANE MARKET

The current membrane market is led by the membrane processes industries for the production of ultrapure and potable water as well as for process-water treatment. The microfiltration market is approximately US\$ 30 million per annum with an annual growth rate of 10 %. This market growth comes mainly from its usage as a pre-treatment filter for pure water production. Currently, all the

microfiltration membranes are imported from abroad.

The ultrafiltration membranes are used for preparation of ultrapure water in semiconductor industries (US\$ 3 million) as shown in Table 1 and for treatment of electro-deposition painting system in automobile industries (US\$ 2-3 million). The rest of industrial applications including oil/water separations stands at US\$ 5 million per annum. Water purifier for home usage by using ultrafiltration membranes is getting more popular and its market is currently about US\$ 5 million per annum.

Table 1. Ultrafiltration Membrane Modules Market for Ultrapure Water Production

Semiconductor Producer	Membrane	Market (US\$ million)
Samsung	Asahi Kasei	2
LG	Asahi Kasei	0.5
Hyundai	Nitto Denko	0.3
Misc.		0.2
Total		3

Table 2. Major Domestic Reverse Osmosis Plants

Plant	Capacity (m ³ /day)	Usage
Hyundai Petrochemicals	70,000	boiler and process water
Samsung General Chemicals	55,000	boiler and process water
A-Electronic Co.	25,000	ultrapure water
B-Electronic Co.	20,000	ultrapure water
Kia Motors	10,000	process water
Yukong	9,000	boiler feed water
Hyundai Refinery	8,000	boiler and process water
Tae Gu Dyeing Complex	2,400	boiler feed water

The reverse osmosis membrane, mostly for water treatment, holds the biggest share in Korea membrane market. Its market size for membranes modules is about US\$ 35 million per annum. Reverse osmosis membranes in industries have been used primarily for treatment of boiler feed water and process water, and production of ultrapure water. The major domestic reverse osmosis plants are listed in Table 2. Recently, the market of water purifier for home usage has been expanded very rapidly and consumed almost 60 % of reverse osmosis membranes as listed in Table 3. In the water purifier for home usage, ultrafiltration and reverse osmosis membranes are competing each other. The pharmaceutical and biochemical industries have also used membrane process as a standard process.

Table 3. Domestic Market of Reverse Osmosis Modules (1996)

	Market (million US\$)	Percentage (%)
Industrial	14	40
Home Usage	21	60
Total	35	100

The water treatment market is expected to continue to lead the domestic membrane market for the foreseeable future. Tighter environmental regulation will stimulate the application of membranes for improvement of water and air quality. For example, membranes for separation of volatile organic compounds will be commonly used in many painting and coating industries. The membrane applications in chemical and biochemical industries, in particular, are expected to grow rapidly in a near future, which constitutes almost 50 % of the market in the developed countries such as USA.

Membrane Industries: Until recently all the membranes and membrane modules had been imported from abroad. Many domestic engineering companies have designed systems with the imported modules and applied them to water treatment until the last decade, and have urged polymer producers to develop cheap membrane modules. This market has encouraged R & D for membranes, resulting in the production of reverse osmosis and ultrafiltration membranes. Nowadays, KOLON, SK Chemicals and HYOSUNG T&C have been producing ultrafiltration membranes and SAEHAN has quite recently started to produce reverse osmosis membranes. KOLON has produced ultrafiltration membranes for potable water production for home usage and is producing hollow fiber membranes for hemodialysis whereas SK Chemicals has concentrated on industrial ultrafiltration membranes. SAEHAN has produced reverse osmosis membranes for potable water and expanded its production to industrial applications. In general, the membrane industry in Korea has been developed recently, but it is expected to grow swiftly.

MEMBRANE R&D PROGRAM FOR ENERGY SAVING

Projects accomplished under the sponsorship of RaCER under MOCI. constitute two main streams of membrane technology ; liquid separation and gas separation. Not only the development of membrane materials but also the development of energy-saving membrane processes have been focused. A total of 12 projects are coordinated by the Cooperative Research Center. Total R&D budget for this project was about 5 million US dollars for the year 1993-1998. CRC is also seeking for an international partner for the project to develop the materials, modules and the processes.

Multi-national enterprises are encouraged to participate in the program for future collaboration with the Korean companies, universities and research institutes.

Table 4. Government Supported Membrane R&D Program for Energy Saving

Title	Institute
Development of Optimum System for Concentration and Drying Process	Hanyang U.
Development of Energy-Saving Industrial Organic Concentration Systems	SKEC-Hanyang U.
Strategic Research on the Extension of Membrane Separation Systems	Membrane Soc.
UF Ceramic Membrane Module for Food Applications	Dongsuh Ind.
Concentration Systems for Fine Chemicals by RO	Hyundai-Yonsei U.
Plate-and-Frame type Membrane Module for RO and PV	Hanyang-Hannam U
UF Tubular-type Membrane Module for Dairy Industries	Seoul Nation U.
Rotary Disk-type Membrane Module for Concentration of Emulsion	Yonsei U.
Organic Acid Concentration by PV	Dongan Eng.-KIU
Oxygen Enrichment Systems for Combustion Uses	Kolon-KIST
Nitrogen Enrichment Systems for Food Preservations	Daelim Ind.
	-DGU. , KAIST
	- Food R&D Center
Ultra High Purity Hydrogen Purifying System Using Membranes	Daesung Sanso
	- KRICT