Development and Applications of Membrane Technology in Korea

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ABSTRACT

In the last 10 years, membrane science and technology in Korea have grown fast in terms of basic research and process applications. Even the first large commercial membrane plant in Korea was an ion-exchange membrane process built in 1975 for the production of table salt with an annual capacity of 150,000 tons of salt, membrane processes could not draw general interests from industry not until 1987 when a reverse osmosis plant for the production of process water with a capacity of 10,000 m^3/day was built by Kugdong Petroleum Co. . Today, the production of water by RO over the capacity of 140,000 m^3/day is in operation or under construction in Korea. Consumption of ultra pure water increases sharply in recent years mainly due to the rapid expansion of semiconductor industry and the introduction of ultra high pressure boilers for power plants.

Hemodialysis was one of early research activities in Korea mainly conducted at a few universities and government laboratories but various membrane processes including pervaporation, electrodialysis, and nanofiltration have been developed by several universities and industries in these days. The foundation of the Membrane Society of Korea in 1991 has accelerated the wide spread of membrane processes in Korean industry through its strong membership, conferences, workshops, symposiums, and Membrane Journal.

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 an major technology. One of the largest industrial wastewater treatment plants in Asia with a daily capacity of 10,000 m^3 using NF and RO was constructed in a Hansol paper manufacturing plant. An Iron manufacturing plant started a series of pilot tests for the installation of membrane processes to treat the effluents of wastewater treatment plant for recycle. Also membrane treatment of leachate from municipal landfill sites is planned.

Introduction

The first large membrane process in Korea was installed in 1975 at a Hanju plant that has an ion-exchange membrane process for the production of table salt with an annual capacity of 150,000 tons of salt. Membrane processes had not drawn general interests from industry not until 1987 when a reverse osmosis(RO) plant was built in Kugdong Petroleum Co. for the production of process water with a capacity of 10,000 m^3/day from a brackish water source. Membrane technology has grown fast in terms of basic research and process applications in the last few years. Nowadays RO plants for the production of over 140,000 m^3/day of process water are in operation or under construction in Korea.

Due to the rapid expansion of semiconductor industry and the use of high pressure boiler by power plants, demand of ultrapure water has been increased sharply in the last few years.

As the government regulations on waste discharge are getting tighter and heading toward the total discharge mass bases rather than the present concentration control, membrane processes have emerged as a major technology for the treatment and reuse of wastewaters.

Until the late 1970's membrane research in Korea was limited to the area of hemodialysis and biocompatible membranes. However a significant increase in research activity has been observed in last 10 years. Furthermore the foundation of the Membrane Society of Korea(MSK) in 1991 has accelerated the wide spread of membrane technology in Korea through its strong membership, conferences, symposiums, workshops, and Membrane Journal.

Membrane Research

Early membrane research in Korea was conducted mainly by the group of Dr. Kim U.Y. of KIST and late professor Kim K.Y of Hanyang Univ.. A young scientists trained oversea have joined the university and research laboratories at the beginning of 1980's research fields have been diversified from bio-medical membranes to RO, UF, GS, PV and LM. According to the review paper by Dr. Kim U.Y. of KIST, the total number of papers related to membrane was 49 for the period of 1979 - 1988. As summarized in tables 1 and 2, the number of research papers published in Membrane Journal and presented at the spring and fall meetings of MSK has increased sharply in the last five years. Even though main research areas are still UF, RO, GS, and PV, it can be seen that most of membrane processes are covered. A similar pattern was also observed in the research reports sponsored by Ministry of Science & Technology as shown in table 3.

Table 1. Classification of research papers published in Membrane Journal.

FIELD \ YEAR		1991	1992	1993	1994	1995*	Sum
MF	A						0
	B				1		1
UF	A		2		1		3
	B	1					1
NF	A						0
	B						0
RO	A			5	3	1	9
	B				2		2
GS	A			1			1
	B		2	2	5		9
PV	A	3			1	1	5
	B	1			1		2
IX	A			1	2	1	4
	B				1		1
LM	A					2	2
	B						0
BF	A					2	2
	B					2	2
IM	A			1			1
	B			1			1
Miscellaneous			1	4	2	1	8
Sum		5	5	15	19	10	54

Table 2. Classification of papers presented at annual conferences of the Membrane Society of Korea

FIELD \ YEAR		1991	1992	1993	1994	1995*	Sum
MF	A	2	2		3	2	9
	B		1	3	2	1	7
UF	A	2	1	4	6	8	21
	B		1	4	7		12
NF	A						0
	B				2	1	3
RO	A	1	1	6	3	1	12
	B	2	4	2	3		11
GS	A	2	7	4	10	3	26
	B	1	3	1	3		8
PV	A		1	3	3	3	10
	B		4	5	2	3	14
IX	A			4	1		5
	B		1				1
LM	A			1			1
	B				2		2
BF	A			1			1
	B			1			1
IM	A		3	3	3		9
	B		1	1		1	3
Miscellaneous		3	10	7	8	4	32
Sum		13	40	50	58	27	188

Table 3. Classification of research reports sponsored by Ministry of Science & Technology

FIELD \ YEAR		1983	1985	1987	1988	1989	1990	1991	1992	1993	Sum
MF	A					1	1	1			0
	B										0
UF	A						1	1			2
	B								1		1
RO/NF	A										0
	B										0
GS	A				1			1		2	4
	B								1		1
PV	A					2		1		3	6
	B				1		1		1		3
ED	A										0
	B							1			1
LM	A				1	1					2
	B	2	1	1			2	2			8
Miscellaneous						3	2	2	1	5	13
Sum		2	1	1	3	7	7	9	4	10	44

Note

- MF : microfiltration UF : ultrafiltration NF : nanofiltration RO : reverse osmosis GS : gas separation PV : pervaporation ED : electrodialysis IX : ion exchange LM : liquid membrane BF : bag filter IM : inorganic membrane
- A : membrane materials & theory B : membrane applications
- * : the first half of 1995

Research activity on the application of membrane is low compared to the research related to the theory and mechanism of membrane formation. Therefore, it is highly required that development of membrane processes based on existing commercial membrane has been done by industry.

Membrane Applications

Process waters ; Korea has generally a good supply of fresh water in most parts of country. However some industrial complex areas have experienced the shortage of water supply mainly due to the fast expansion of industry and to the severe draught in last few years, The quality of supply water also becomes worse because of wastewaters discharged into the water supply system.

Ion exchange and softening have been major processes for production of process water in Korea. The steady increase of total dissolved solids in most water supply has led industry to the adoption of membrane processes. Particularly membrane appears to be the only option to produce process water for the plants located at newly developed area of west coast mainly because its source water has TDS concentration in the

ranges ; 500 - 1500 mg/ℓ. It is expected that demands for low-pressure RO membrane will increase in near future.

Ultrapure water ; Fast growing semiconductor industry is one of main users of ultrapure water in Korea. As the production of high density chips increase sharply, the consumption of ultrapure water also increases significantly in recent years. There should be more research required for the development of super clean membrane modules and distribution system. Another potential big user of ultrapure water is power plants for the super high pressure boiler feed water. Most of old boiler in Korean power plant are expected to be replaced by super high pressure boiler in next 10 years. Recent study conducted by Korea Electric Power Co. suggested that a hybrid system of IX and RO would be the main water treatment process for most of raw water sources that are supplied to power plants in Korea.
Demands for ultrapure water in other industries such as pharmaceutical, fine chemicals, etc. are not large compare to the two industries but a steady increase of ultrapure water is expected. Drinking water production by home RO units shows sharp increase recently as people are getting less confident for the quality of tap water supply. However, the research on membrane application to the public water production is just beginning.

Wastewater treatment and reuse ; As effective January 1st. 1996, a tighter discharge regulation is applied to most industries in Korea. Therefore the existing treatment plants need renovation to meet the new rules. Membrane processes are seriously considered as an alternative technology by many industries. One of the largest industrial wastewater treatment plant in Asia with a daily capacity of 10,000 m^3 using NF and RO was constructed in a paper manufacturing plant in order to reclaim the wastewater generated in processes. A steel company started a series of pilot tests for the installation of membrane process to recycle the effluent of wastewater treatment plant. Several municipalities also plan to install membrane process for the treatment of landfill leachate. As government encourages the reuse of gray water in large building, membrane processes with bioreactor have been investigated by some engineering companies. It is expected that cost effective membrane bioreactor draw major interests from both industry and academia.
Membrane applications to wastewater treatment, however, require extensive pilot testing before a process is designed. There are many cases where membrane processes were failed not because of membrane itself but because of insufficient pilot testing.

Summary

Membrane research has increased significantly in last ten years. However, more research effort is required for the applications and engineering of membrane processes and the development of membrane modules. Korean industry is beginning to accept membrane technology as a major process for the production of process water and ultrapure water. In areas of wastewater treatment and reuse, some industries are still cautious to install membrane processes.