CHAPTER III

METHODOLOGY

The membrane experiment was conducted at the laboratory of the Department of Environmental Engineering, Faculty of Engineering, Chiang Mai University.

3.1 Feed solution

3.1.1 Concentration Polarization

The feed solution was prepared using sodium fluoride (J.T. Baker, USA.). The fluoride concentration in the feed solutions was varied at 0, 10, 25, and 50 mM.

3.1.2 Silica Fouling

In the silica fouling experiment, sodium silicate and sodium metasilicate nonahydrate (Wako Pure Chemistries, Ltd., Japan) were employed to prepare the polymerized silica and colloidal silica, respectively. Water containing a fluoride concentration of 15 mg/L was combined with silica concentrations of 0, 100, and 300 mg/L to prepare the feed solutions.

3.2 Material

3.2.1 Feed tank

A plastic container with a 15 L capacity was used to contain the feed solution.

3.2.2 Temperature-controlling water bath

In this research, temperature was held constant at 25°C by using a temperature-controlling water bath, which could control temperature within the range of 0 to 70°C.

3.2.3 Membrane and Membrane Module

A cross-flow membrane test unit, the C10-T Module, was the membrane module obtained from the Nitto Denko Corporation, Japan. The membrane module and the equipment of the membrane module are shown in Figures 3.1 and 3.2, respectively. The flat sheet UTC-70 membrane, which is an ultra low pressure reverse osmosis (ULPRO) membrane, was obtained from the Toray Corporation, Japan; it provided a membrane area of 60.0 x 10^{-4} m^2. Figure 3.3 shows the UTC-70 membrane.

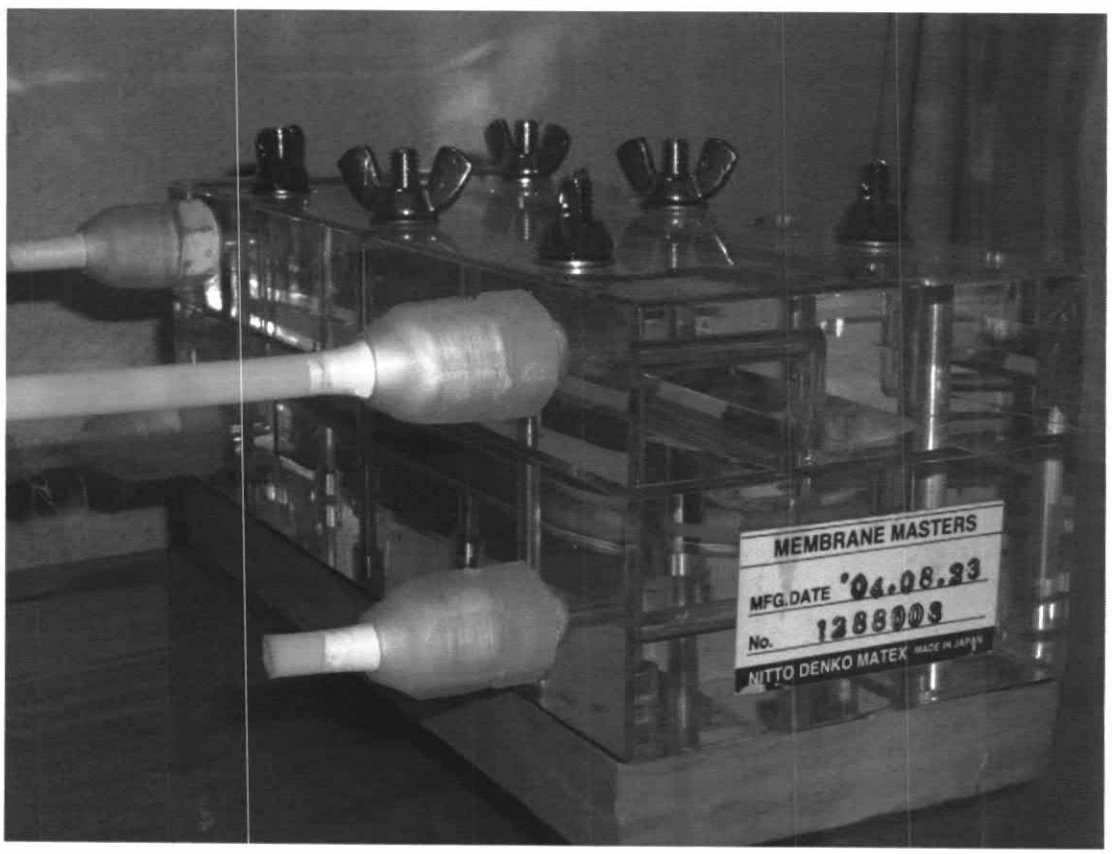

Figure 3.1 Membrane module

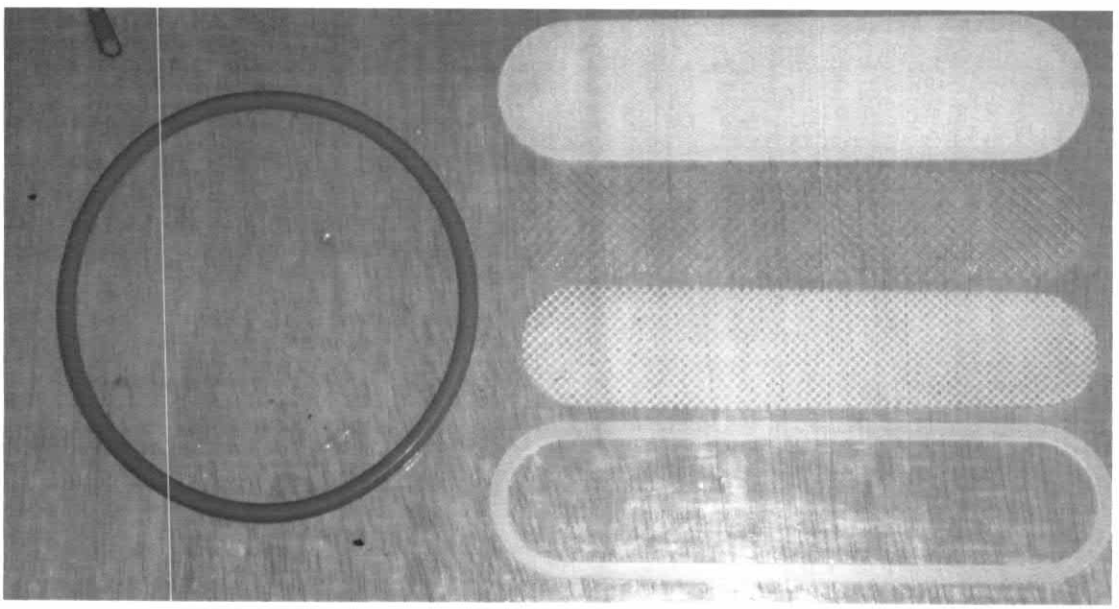

Figure 3.2 Equipment in the membrane module

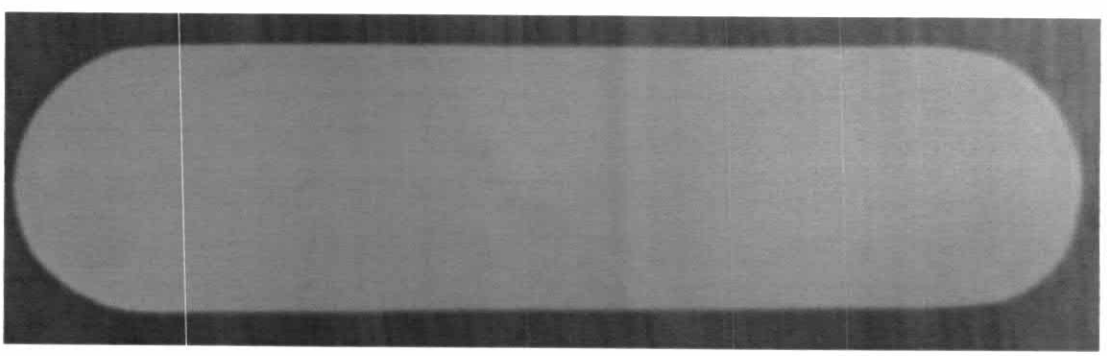

Figure 3.3 UTC-70 membrane

3.2.4 Pump

The gear pump was from the Iwaki Company, Japan. It could be operated at maximum operating pressure of 0.55 MPa, and a maximum capacity of 2.0-2.4 liters per minute was employed in this study.

3.2.5 Pressure indicator

Two pressure indicators were used to detect the influent feed solution pressure and concentrated solution pressure.

3.2.6 Valve

The bypassed water valve and concentrated water valve were set in the membrane experiment system. In this study, the bypassed water valve was closed and the concentrated water valve was used to adjust the pressure in the system.

3.2.7 Flow meter

The flow meter was set to detect the water flow through the membrane experiment system.

3.3 Membrane experimental procedure

This research was conducted in a cross-flow membrane test unit (C10-T Module, Nitto Denko Corp.) using the UTC-70, an ULPRO Toray membrane. A membrane area of 60.0 x 10^{-4} m^2 was used for the experiment under the operating transmembrane pressures of 0.1, 0.3, and 0.5 MPa. The temperature was controlled at 25°C by using a temperature-controlling water bath. A schematic diagram of the cross-flow filtration membrane experiment process is shown in Figure 3.4.

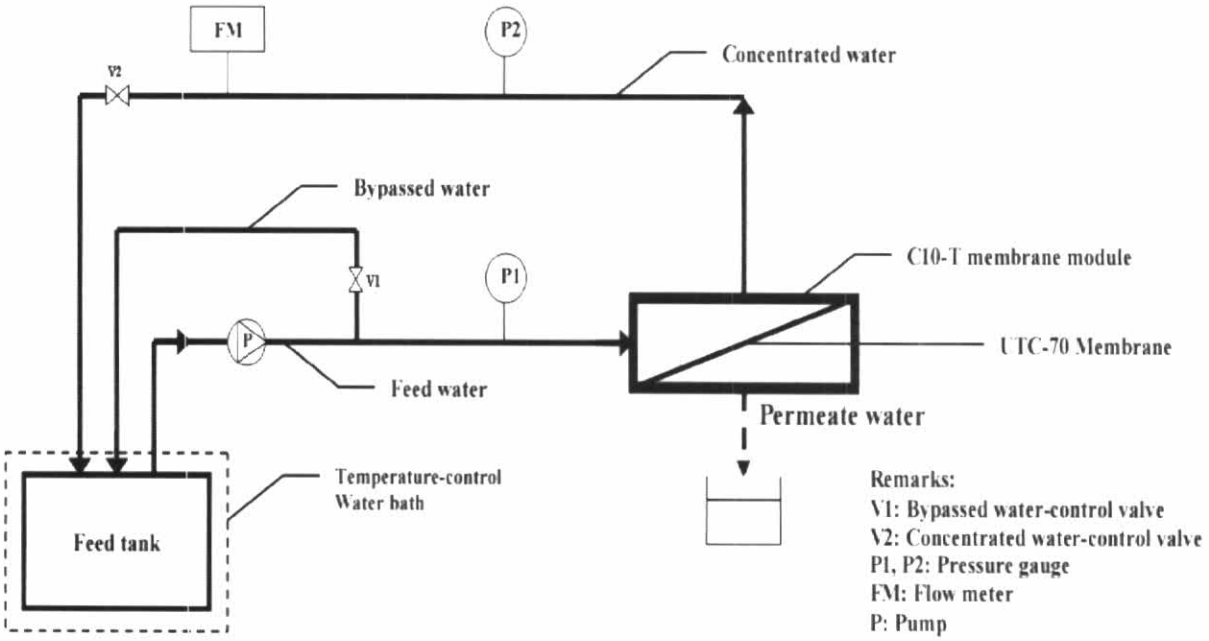

Figure 3.4 A schematic diagram of the cross-flow filtration membrane experiment process

The membrane experimental set up and membrane experimental apparatus are depicted in Figure 3.5.

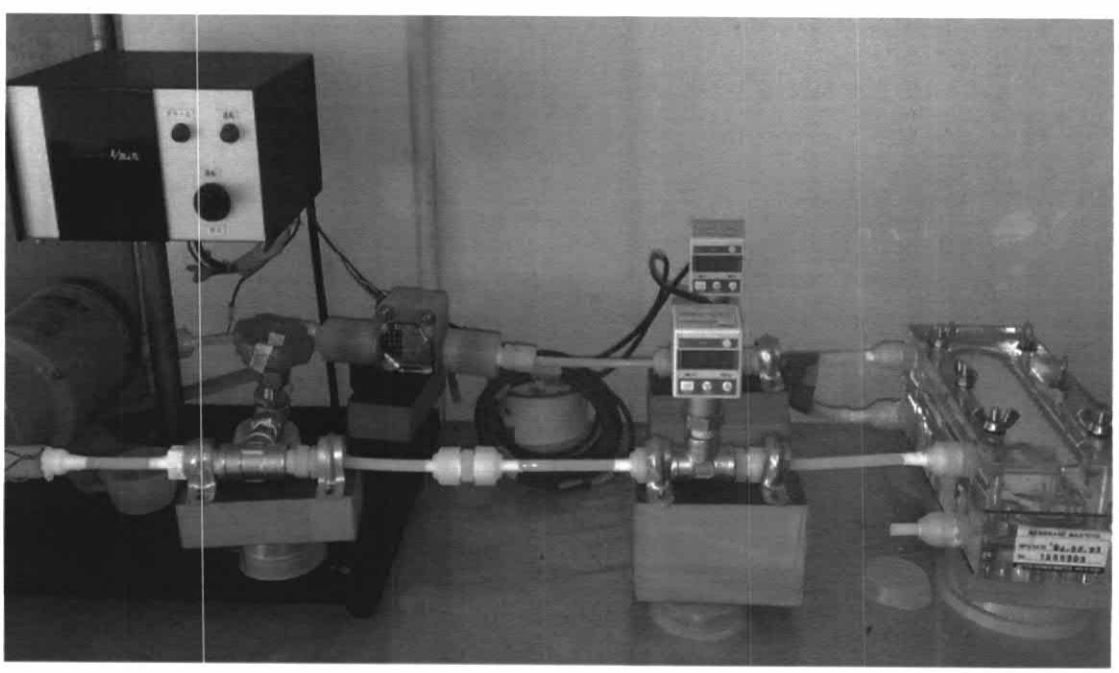

Figure 3.5 Membrane experimental set up and membrane experimental apparatus

3.4 Membrane experiment

3.4.1 Concentration polarization

1. 10 L of the fluoride feed solution in a feed tank was put through the membrane experiment process. The bypassed valve was closed, whereas the concentrated valve was opened. The concentrated water was recycled to the feed tank.

2. The permeate flux was observed every 30 minutes.

3. At 1,000 ml of the obtained permeate water, the permeate flux was recorded and determined by using a 10 ml measuring cylinder to identify the time when the permeate water reached 10 ml.

4. The permeate water and concentrated water were collected in a 120 ml plastic bottle for determining the fluoride concentrations.

5. The membrane experiments for the other runs were done.

The concentration polarization experimental conditions are presented in Table 3.1.

Table 3.1 Concentration polarization experimental conditions

Sample	Transmembrane pressure, TMP (MPa)	Fluoride concentration (mM)
C1	0.1	0
C2		10
C3		25
C4		50
C5	0.3	0
C6		10
C7		25
C8		50
C9	0.5	0
C10		10
C11		25
C12		50
C13		75

3.4.2 Silica Fouling

1. Water containing a fluoride concentration of 15 mg/L was combined with different silica concentrations of 0, 100, and 300 mg/L to prepare the feed solutions.

2. 10 L of feed solutions were experimented using the same steps that were used in the concentration polarization experiment.

The silica fouling experimental conditions are presented in Table 3.2.

Table 3.2 Silica fouling experimental conditions

Run no.	Transmembrane pressure, TMP (MPa)	Fluoride concentration (mg/L)	Silica concentration (mg/L)
1	0.1	15	0
2		15	100
3		15	300
4	0.3	15	0
5		15	100
6		15	300
7	0.5	15	0
8		15	100
9		15	300

3.5 Analytical method and instrument

The fluoride concentrations in the permeate water (C_P) and concentrated water (C_B) were analyzed in accordance with Standard Method 4110, Section 4110B by using ion chromatography (Dionex, ICS-2500) with chemical suppression of eluent conductivity.