CHAPTER III
EXPERIMENTAL

Figure 3.1 illustrates the experimental set-up of the multistage foam fractionation unit used in this study. The multistage foam fractionation column was comprised of a water-jacketed stainless-steel cylinder having a jacket diameter of 30 cm, an internal column diameter of 20 cm, and a tray spacing of 15 cm. Each tray had 16 bubble caps with a weir height of 5 cm and a cap diameter of 2.5 cm. A sample port was located at the base of each tray for taking liquid samples. Each tray had a glass window for visual observation. Three foam heights of 30, 60, and 90 cm from the top tray of the column were studied. A feed solution containing each surfactant at a fixed concentration was continuously fed into the multistage foam fractionation column by using a peristaltic pump at different flow rates in a range of 20-200 mL/min (0.7215-5.77 L/min m^2) and the feed solution entered the column at the top position of the highest tray. The pressurized air flow rate was regulated by a rotameter in the range of 30-90 L/min and was introduced to the bottom of the column. The column operating temperature was held constant at 25°C by using a circulating cooling-heating bath to circulate water through the water jacket around the column. The studied system was first operated to determine the time to establish steady state, which was around 20 hours. Steady state was ensured when all measured parameters were invariant with time. The result shows that the multistage foam fractionator requires a much longer time to reach steady state as compared to only 6 h reported in the previous study for the single-stage unit (6). After the studied system was operated longer than the steady state time of 20 hours, the foamate at the top of the solution was collected at three different heights (30, 60 and 90 cm) from the top tray of the column. The foam collected was frozen, thawed, and then weighed to measure the mass and volume of the collapsed foamate at room temperature (25 – 27 °C), which are used to indicate the foam wetness (g of collapsed foam solution/L of foam) and foam production rate (mL/min). The samples of the feed solution, the collapsed foamate and the effluent were analyzed for surfactant concentration. The concentration of SDS was measured by a total organic carbon analyzer (TOC) (Shimadzu, TOC-5000A). The concentration of CPC was measured by using a UV-Visible spectrophotometer (Perkin Elmer, Lambda 10) at a wavelength of 260 nm. The concentration of Span80 was measured by the TOC. The fractionation column was thoroughly cleaned with distilled water before starting the next experiment. All of the experiments were performed at least three times to ensure reproducibility of the results and the mean values of the experimental data were taken to evaluate the process performance in the recovery of these three surfactants. By performing mass balance of surfactant, the average error was in the range of 5-13%.

In addition, the critical micelle concentration (CMC) of each surfactant was determined from the concentration, where the surface tension versus surfactant concentration shows an abrupt change in the slope. The measurement of surface tension values of solutions containing different surfactant types and concentrations was carried out by using a Du-Nouy ring tensiometer (Kruss, K10T).

Moreover, experiments to measure foamability and foam stability were conducted by using a glass column having an internal diameter of 5 cm and a height of 100 cm. A quantity of 250 mL of solution containing different surfactant types and a fixed surfactant concentration of 50% of its CMC was poured into the column and then the solution was sparged with a constant air flow rate of 0.35 L/min. The foam height was measured as a function of time until the maximum foam height was reached at 90 cm. The time required to obtain the maximum foam height of 90 cm is used to express the foamability of the system, which indicates the ability to generate foam. To quantify foam stability, the air introduced into the column was terminated, and the foam height versus time was then measured. The foam stability is expressed in terms of time required for the complete collapse of foam. All experiments were carried out at room temperature (25 – 27 °C).

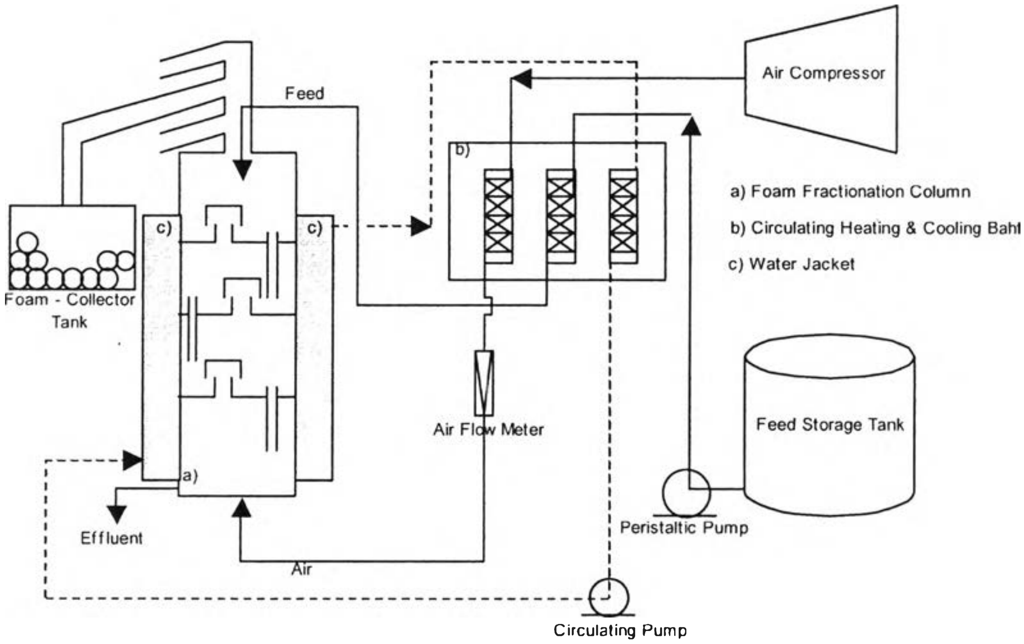

Figure 3.1 Schematic of experimental multistage foam fractionation system.