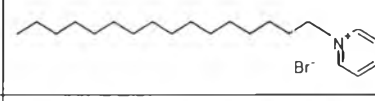
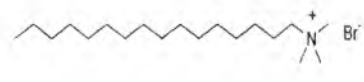
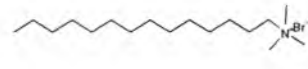
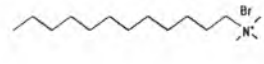
CHAPTER III
EXPERIMENTAL

3.1 Materials

Flour different cationic surfactants were chosen for study. Hexadecylpyridinium bromide (CPB, >97% purity), Hexadecyltrimethylammonium bromide (CTAB, >96purity), Tetradecyltrimethylammonium bromide (TTAB, >98% purity), and Dodecyltrimethylammonium bromide (DTAB, >98% purity) were supplied from Fluka (Switzerland). Distilled water was used in all experiments. Manufacturer-supplied information about the chemicals used is shown in Table 3.1

Table 3.1 Chemical properties of the studied surfactants

Surfactant	Chemical formula	Molecular weight	Purity
Hexadecylpyridinium bromide (CPB) C_{16}		384.44	>97%
Hexadecyltrimethylammonium bromide (CTAB) C_{16}		364.48	>96%
Tetradecyltrimethylammonium bromide (TTAB) C_{14}		332.34	>98%
Dodecyltrimethylammonium bromide (DTAB) C_{12}		308.34	>98%

3.2 Apparatus

The multi-stage foam fractionation apparatus used in this study is shown in Figure 3.1. The column did not have water jacket because previous work showed that temperature did not have effect for the separation. The column was built by using acrylic with tray spacing equal to 15cm. The inner and outer diameters of the column are 18 and 18.03 cm, respectively. The unit has multiple stages and could accompany up to 5 stages. Bubble-caps were made from stainless steel with 2 cm of diameter and 6 cm of height and it has 22 bubble caps per tray. Figure 3.2 illustrates the model of bubble-cap tray. The dimensions of the multi-stage foam fractionator are given in Table 3.2.

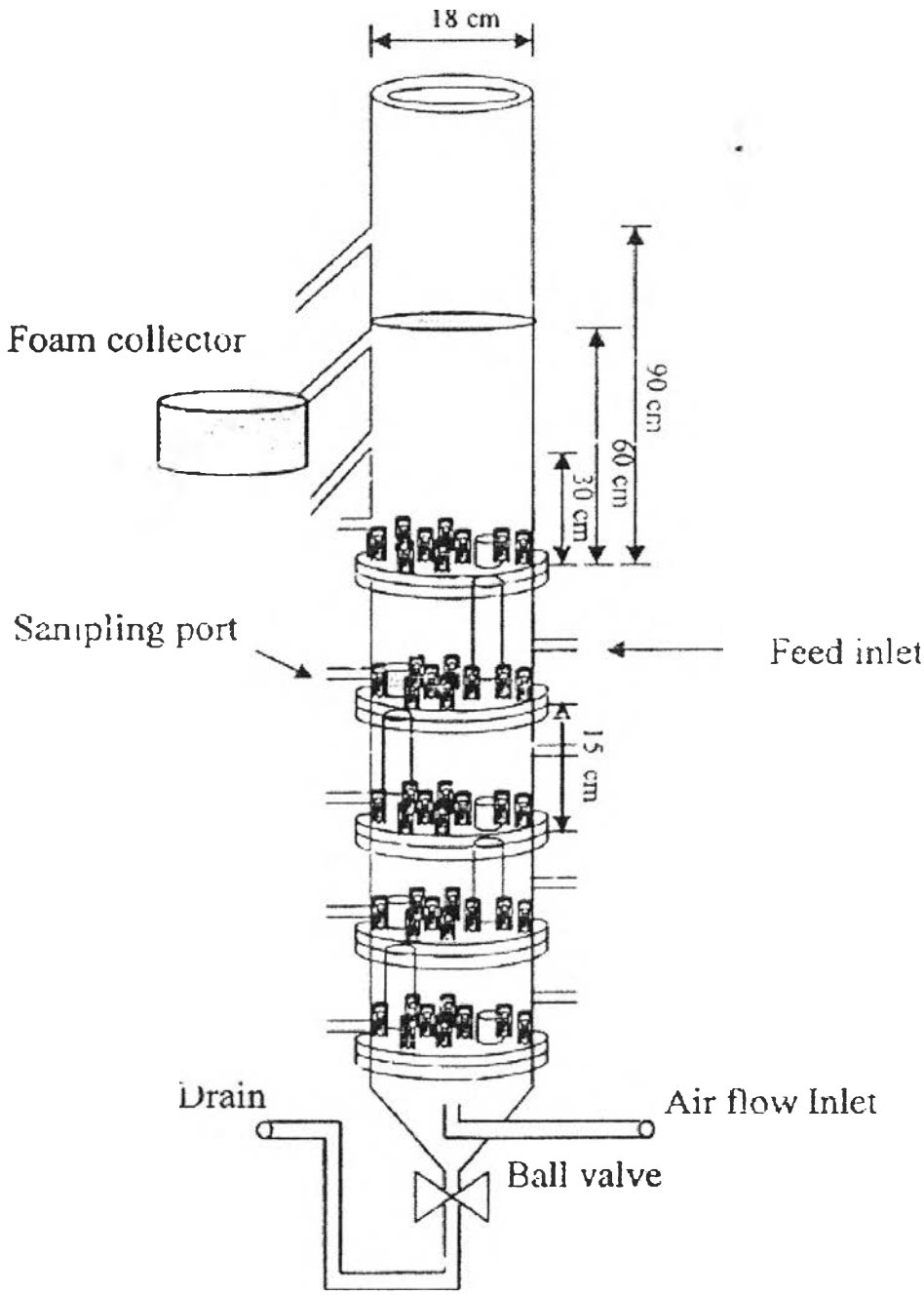


Figure 3.1 Schematic of multistage foam fractionation column.

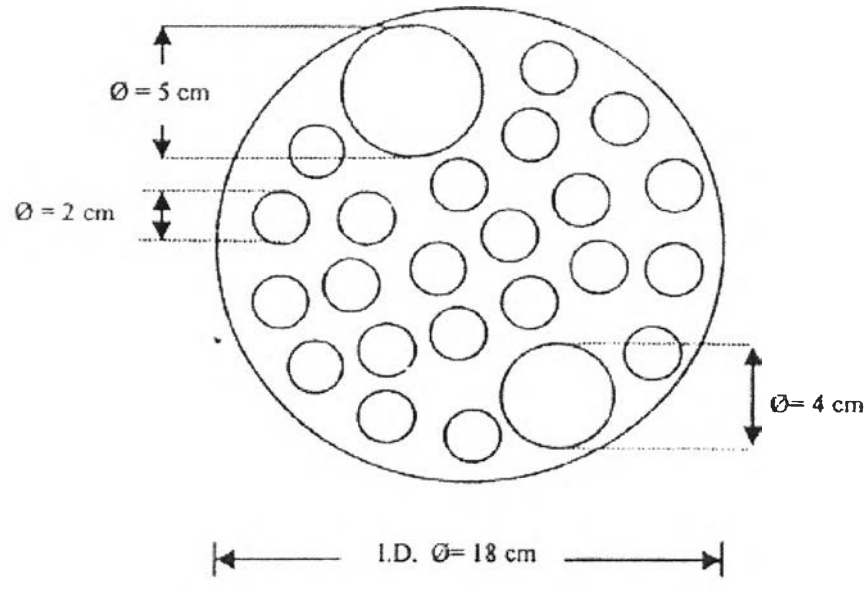


Figure 3.2 Schematic of bubble-cap tray. (Top view)

Table 3.2 Dimension of the multi-stage foam fractionation

Tray spacing	15 cm
Column diameter	
-Inner	18 cm
-Outer	18.03 cm
Weir of bubble cap	
-Diameter	2 cm
-Height	6 cm
Number of bubble caps per tray	22

3.3 Methodology

The foam fractionator was operated in continuous mode with aqueous solution containing surfactant. The surfactant solution was continuously feed a constant flow by using a peristaltic pump. The compressed air was introduced to the bottom tray of the column. The foam was collected at 60 cm from the liquid surface of the top tray. It was received by beaker for measured time. Then, it was frozen, thawed and then weighed to get the foamate volume.

The foam fractionation system was studied under steady state conditions. Steady state was insured when all measured parameters were invariant with time. The surfactant concentration in the feed solution was kept constant at 0.5 CMC of each surfactant. The rang of the operating parameters is summarized in Table 3.3. In each experiment, foam wetness (grams of foam solution/liter of foam), the surfactant concentration (mM) in the collapsed foam solution, and the surfactant concentration (mM) in the inlet and outlet steam were measured. The concentrations of surfactants were measured by Total Organic Carbon.

The critical micelle concentration (CMC) of each surfactant was calculated as the concentration where the specific surface tension versus surfactant concentration shown an abrupt change in slope. The measurement of surface tension of surfactant solutions was carried out by using Contact Angle Instrument (DSA 10, Kruss).

In this research, glass column having internal diameter of 5 cm and a height of 100 cm was used to investigate the foam ability and foam stability for all surfactant solutions. The step of this method stared with pouring a certain amount of 250 ml of solution into the column and it was consequently sprayed by a constant flow rate of air 0.1 L/min. The foam height was measured as a function of time was to indicate the foam ability of the system. When the foam reached the highest level at which it was stable, the air flow was suppressed and then the time that it took for collapse to the half of maximum point was measured as foam stability.

Table 3.3 Operating parameters

Feed inlet -Type of surfactant -Total concentration -Flow rate	 CPB, CTAB, TTAB and DTAB 0.5 CMC 40, 60, 80, 100 ml/min
Air inlet -Flow rate	 40,60,80,100 l/min
Foam height	60 cm
Feed position at tray number	5

3.4 Data Analysis

After the steady state was established, the effects of several parameters on the multi-stage foam fractionation performance were investigated in a continuous mode of operation. Efficiency of the surfactant recovery process was evaluated in terms of %recovery and enrichment ratio as given below:

$$\% \text{ Surfactant recovery} = \left(\frac{(CiFi - CeFe) * 100}{CiFi} \right) \quad (3.1)$$

$$\text{Enrichment ratio} = \frac{Cf}{Ci} \quad (3.2)$$

Where Ci is the surfactant concentration in the influent steam (mM)

Ce is the surfactant concentration in the effluent steam (mM)

Cf is the surfactant concentration in the foam concentrated steam (mM)

Fi is the feed flow rate (ml/min)

Fe is the effluent flow rate (ml/min)