CHAPTER IV
RESULTS AND DISCUSSION

4.1 Effect of SO on the Foaming of SO/SDS Mixtures

4.1.1 System below the CMC of SDS

In this experiment, the mole ratio of SO/SDS was varied from 0.0/1.0. 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2.and the concentration of SDS was fixed at 0.005 M.

Figure 4.1 shows the foamability and foam stability of solutions containing different ratios of [SO]/[SDS] in the absence of calcium ion. The concentration of SDS was fixed at 0.005 M which is below the CMC of pure SDS of 0.008 M. Foam height increases slightly with the ratio of SO due to the increase in total concentration of mixtures while the foam stability is high at all ratios.

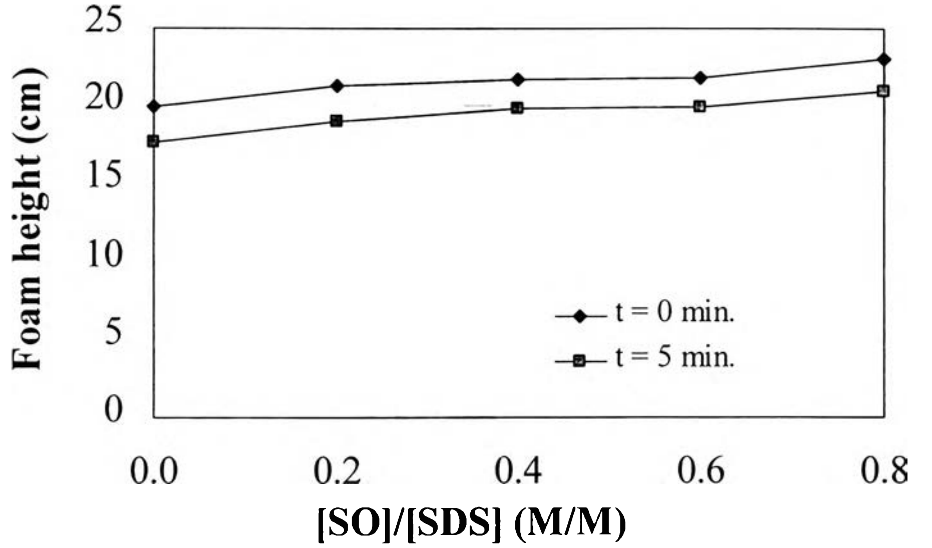

Figure 4.1 Foam height of SO/SDS mixtures at varying SO ratio, [SDS] = 0.005 M

4.1.2 System above the CMC of SDS

The mole ratio of SO/SDS was varied from 0.0/1.0, 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2. The concentration of SDS was fixed at 0.01 M which is above the CMC of SDS. In this system the concentration of SO was varied in order to study the effect of SO on the foaming of SO/SDS in micellar systems.

Figure 4.2 shows the foamability and foam stability of solutions containing different ratios of [SO]/[SDS] with the concentration of SDS fixed at 0.01 M which is above its CMC. It was found that foam height increases slightly at [SO]/[SDS] ratio of 0.2/0.8 but remains constant as the [SO]/[SDS] ratio is increased from 0.2/0.8 to 0.8/0.2. This is because above the ratio of 0.2/0.8, the total surfactant concentration is well above the CMC of the mixture. Foam height of anionic surfactant solution usually reaches a maximum value at around the CMC and remains constant above the CMC. Foam stability of the solution also remains high at all mixture ratios.

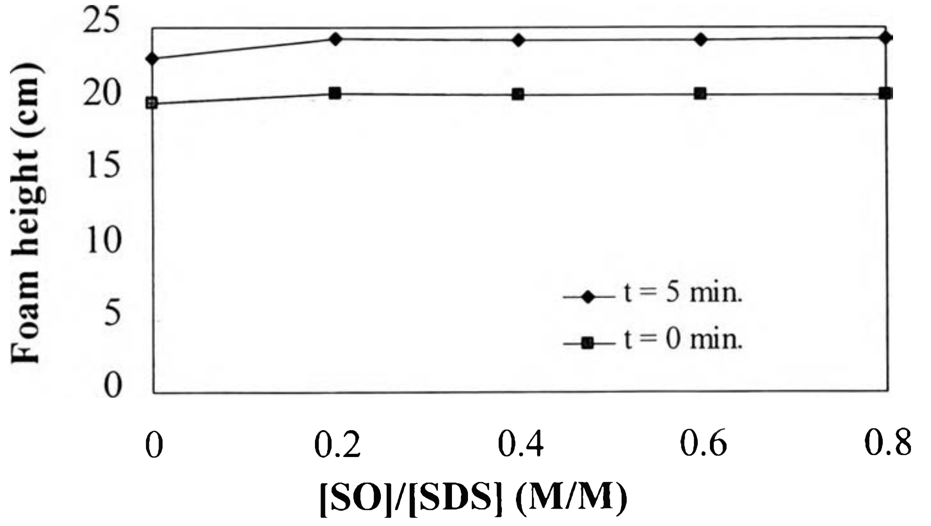

Figure 4.2 Foam height of SO/SDS mixtures at varying SO ratio, [SDS] = 0.01 M

4.2 Effect of Calcium Ion on the Foaming of SO/SDS Mixtures

4.2.1 System below the CMC of SDS at low concentration

In this experiment, the concentration of SDS was fixed at 0.001 M which is well below the CMC of SDS. The mole ratio of SO/SDS was varied from 0.0/1.0, 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2. The calcium ion concentration in the mixture at each ratio was varied to cover the regions above and below the SO/SDS precipitation phase boundary determined by Chintanasathien (1995) and Rodriquez *et al.* (1998).

The results in Figure 4.3 show that foamability and foam stability of the mixtures decrease sharply as soon as a small amount of Ca^{2+} is added. The sharp change occurs even before the calcium concentration reaches the precipitation phase boundary. In such dilute systems, the decrease in foamability and foam stability is due to the reduction in the charge repulsion between head groups of anionic surfactant in the presence of electrolyte.

4.2.2 System below the CMC of SDS at moderate concentration

In this experiment, the concentration of SDS was fixed at 0.005 M which is below the CMC of SDS. The mole ratio of SO/SDS was varied from 0.0/1.0, 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2. The calcium ion concentration of mixtures in each ratio was varied to cover the regions above and below the SO/SDS precipitation phase boundary as in part 4.2.1.

Figure 4.4 shows the results of the systems with the concentration of SDS fixed at 0.005 M which is below the CMC of SDS. It can be seen that foam height decreases gradually as calcium concentration increases with no sharp change at the precipitation boundary. The decrease in foamability with the increase in calcium concentration is due to the decrease in monomeric surfactant concentration in the solution.

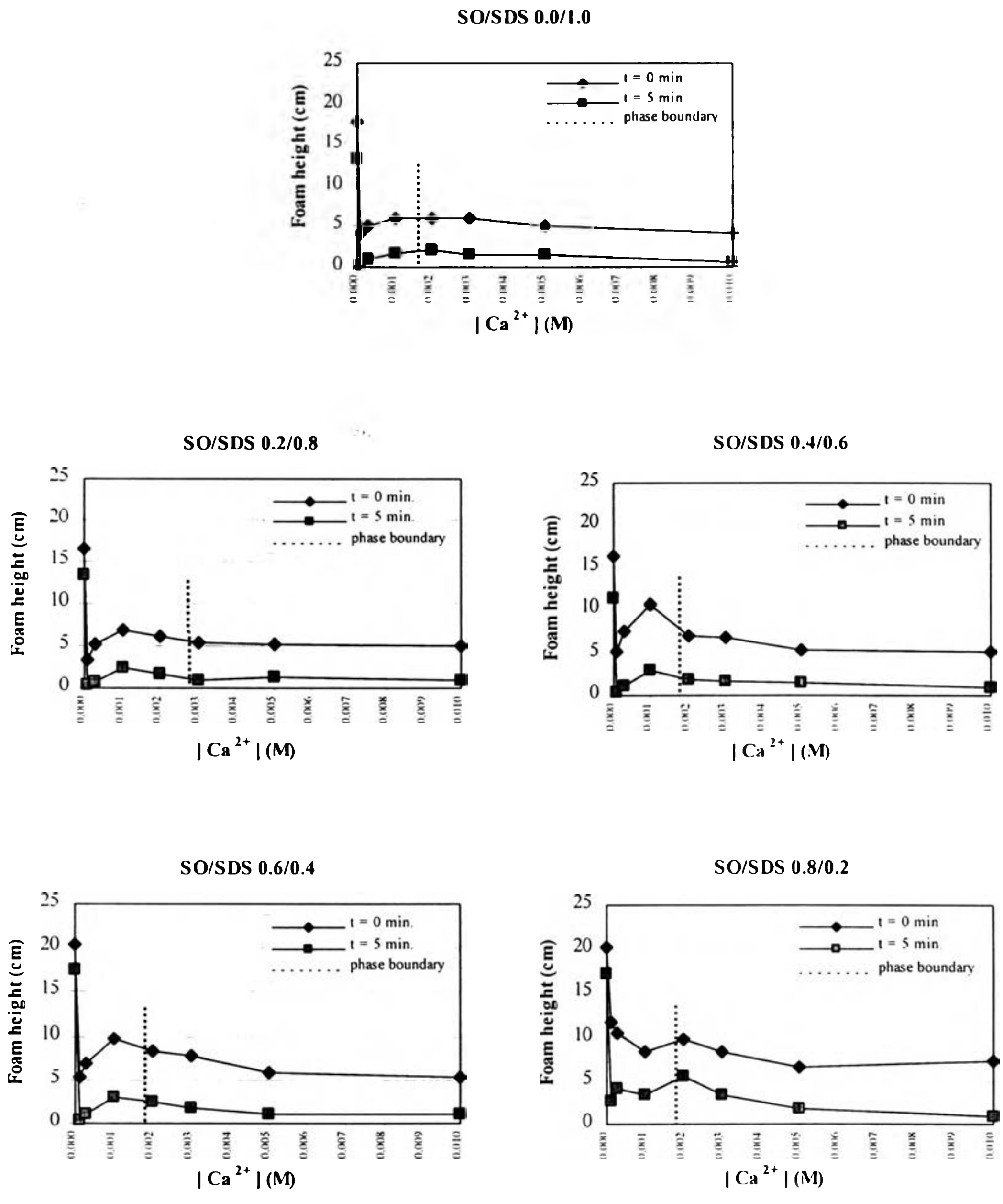

Figure 4.3 Foam height of SO/SDS mixtures at varying $[Ca^{2+}]$, [SDS] = 0.001 M

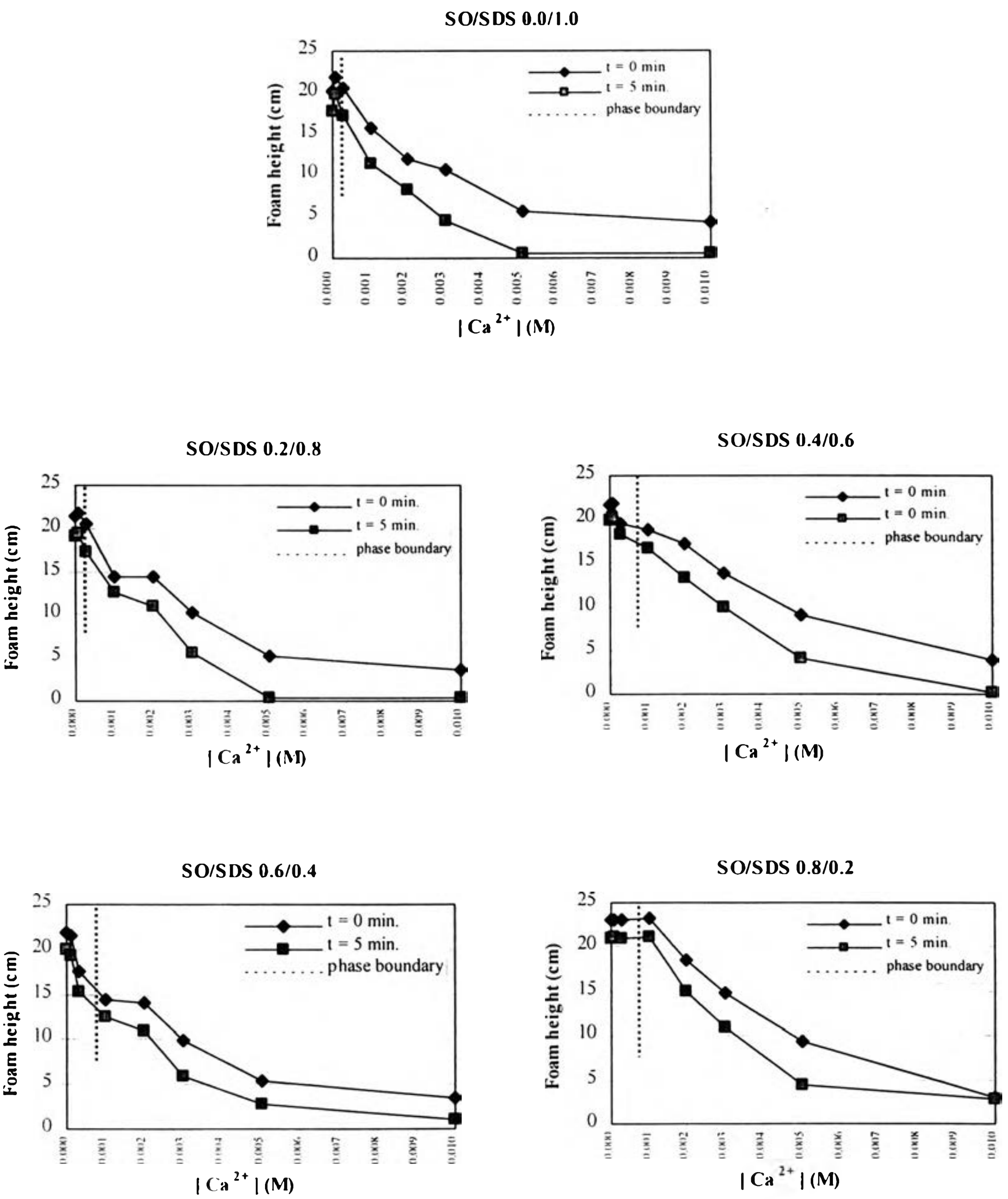

Figure 4.4 Foam height of SO/SDS mixtures at varying [Ca^{2+}], [SDS] = 0.005 M

4.2.3 System above the CMC of SDS

In this experiment, the concentration of SDS was fixed at 0.01 M which is above the CMC of SDS. The mole ratio of SO/SDS was varied from 0.0/1.0, 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2. The calcium ion concentration of mixtures in each ratio was varied to cover the regions above and below the SO/SDS precipitation boundary regions as in previous parts (below the CMC).

Figure 4.5 shows the foaming property of systems with surfactant concentration above the CMC of mixtures, the concentration of SDS was fixed at 0.01 M. It was found that foamability is high even in the presence of precipitates and there is no sharp change at the precipitation phase boundary. The foam height only decreases when calcium concentration is very high because the concentration of surfactant mixtures at that point is reduced to below their CMC.

4.3 Effect of SO on the Foaming of SO/SDS mixtures in the Presence of Ca^{2+}

Figure 4.6 shows the foamability results with varied SO ratio and with SDS concentration fixed at 0.001 M, 0.005 M, and 0.01 M respectively. As the SO ratio increases, not only SO concentration increases, but the amount of calcium/SO precipitate in the system also increases. However, foamability does not decrease with SO ratio. The results show that SO precipitate does not act as an antifoam in this system.

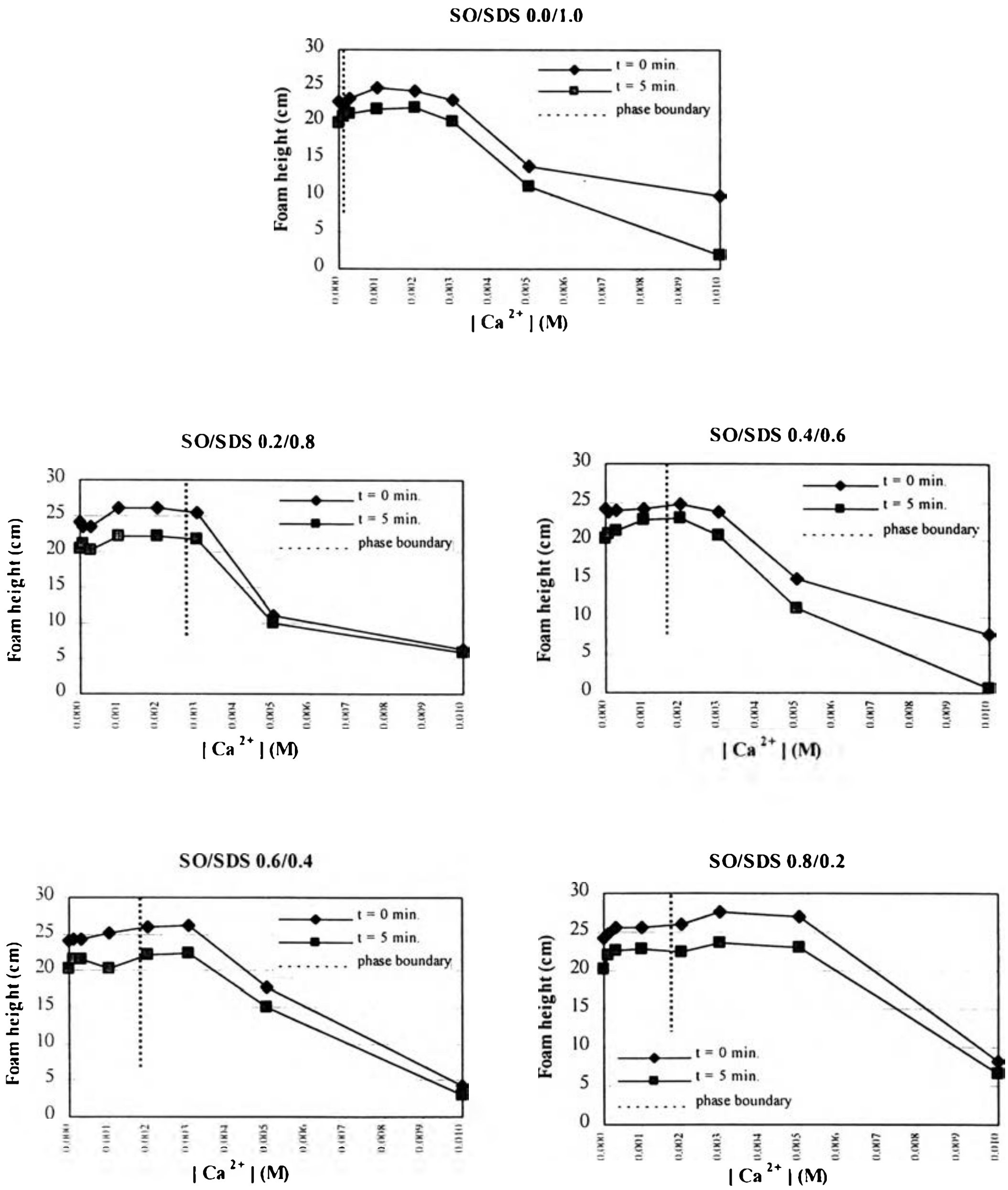

Figure 4.5 Foam height of SO/SDS mixtures at varying $[Ca^{2+}]$, [SDS] = 0.01 M

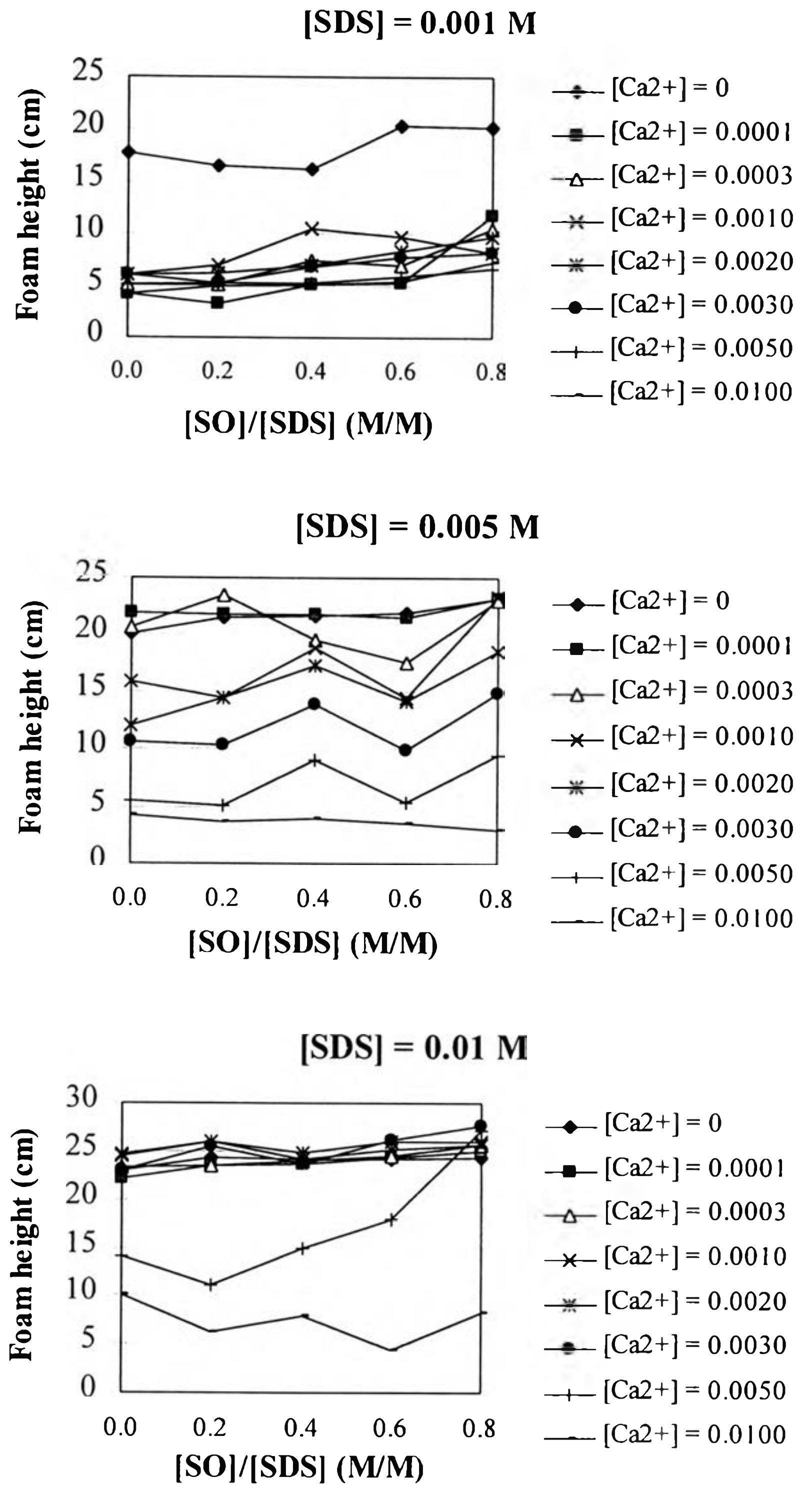

Figure 4.6 Foam height of SO/SDS mixtures at [SDS] = 0.001 M, 0.005 M and 0.01M in the presence of Ca^{2+}

4.4 Comparison of the Foaming of Precipitate-Containing and Supernatant Solutions

The effect of calcium precipitates on foaming of SO/SDS mixtures was investigated by comparing the foaming of precipitate-containing solutions and the supernatant solutions which were prepared by filtering out precipitates from the mixture solutions after the solutions were left to equilibrate for 12 hours at 30 ^{o}C.

4.4.1 System below the CMC of SDS

The concentration of SDS in the mixture solution was fixed at 0.005 M which is below the CMC of SDS. The mole ratio of SO/SDS was varied from 0.0/1.0, 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2. The calcium ion concentration at each ratio was varied to cover the regions above the SO/SDS precipitation phase boundary.

The results in Figure 4.7 show that in all cases, the foamability of supernatant solutions is significantly higher than that of the precipitate-containing solutions. The foamability of the precipitate-containing solutions decreases with an increase in calcium concentration while the supernatant systems decreases only slightly with calcium concentration. The results show that calcium-SDS precipitates may act as an antifoam or foam inhibitor in the precipitate-containing solutions. The presence of SO does not seem to have any significant effect on the foamability of both supernatant and precipitate-containing solutions.

Figure 4.8 compares the stability index of supernatant and precipitate-containing solutions at [SDS] = 0.005 M. At high calcium concentration, foam stability of supernatant and precipitate-containing solutions both decrease dramatically.

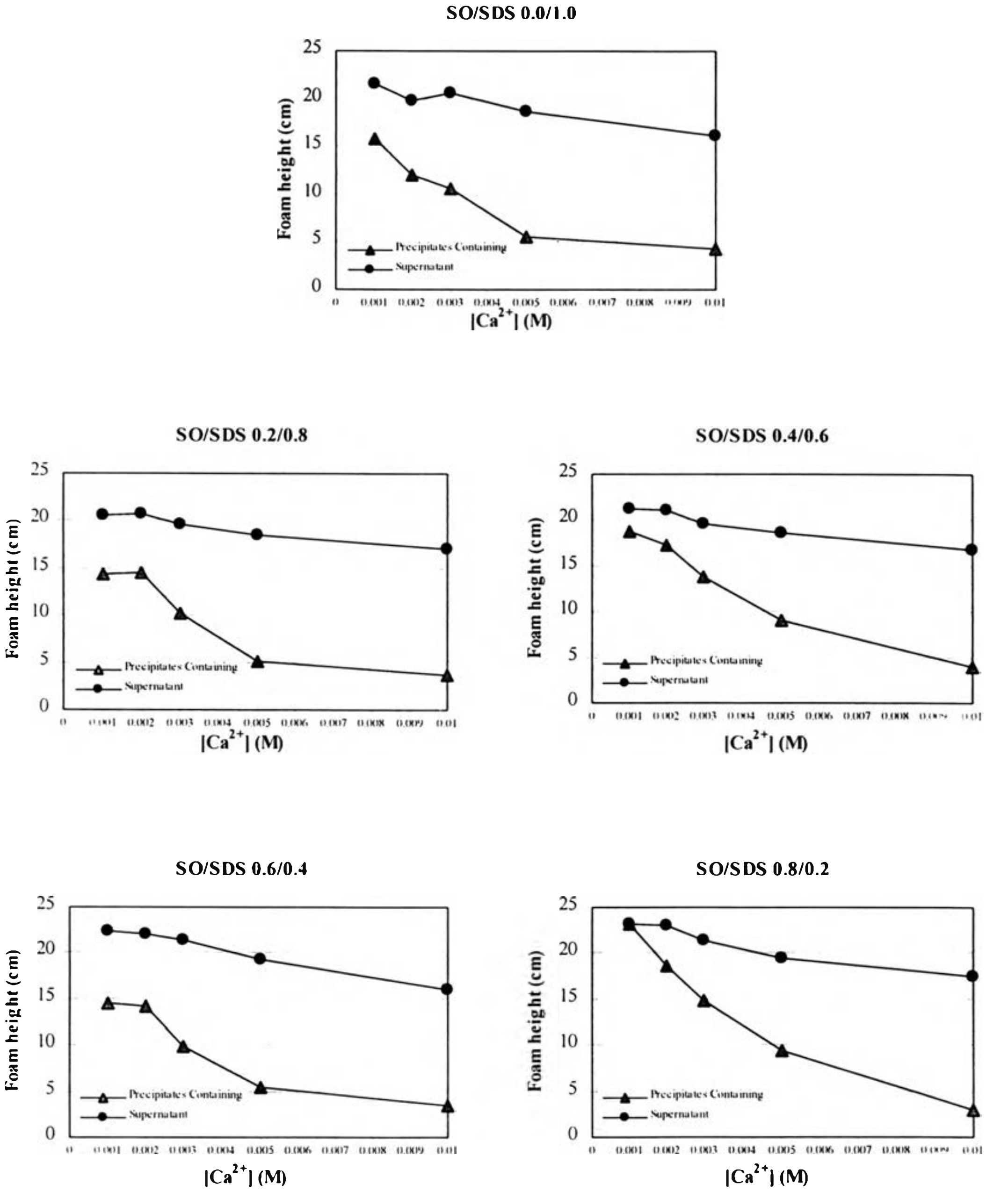

Figure 4.7 Foam height of supernatant and precipitate-containing solutions with varying [SO]/[SDS] ratio and $[Ca^{2+}]$, [SDS] = 0.005 M

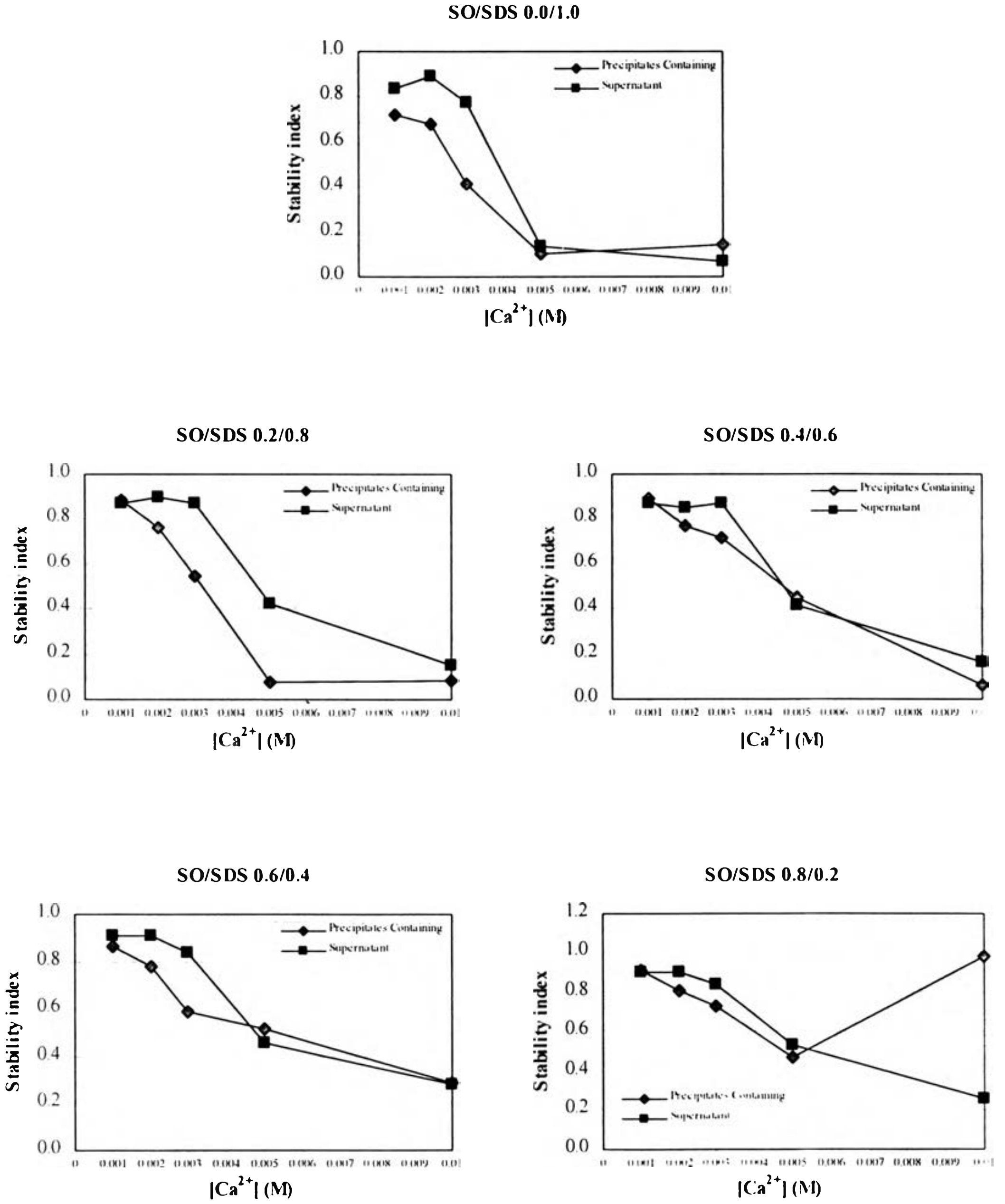

Figure 4.8 Stability index of supernatant and precipitate-containing solutions with varying [SO]/[SDS] ratio and $[Ca^{2+}]$, [SDS] = 0.005 M

4.4.2 System above the CMC of SDS

The concentration of SDS in the mixture solution was fixed at 0.01 M which is above the CMC of SDS. The mole ratio of SO/SDS was varied from 0.0/1.0, 0.2/0.8, 0.4/0.6, 0.6/0.4 to 0.8/0.2. The calcium ion concentration at each ratio was varied to cover the regions above the SO/SDS precipitation phase boundary.

The results in Figure 4.9 show that foamability of supernatant solutions is very close to that of the precipitate-containing solutions at low calcium concentration. There is however a sharp decrease in foamability of precipitate-containing solutions at [Ca^{2+}] around 0.003 M while the foamability of supernatant solutions remains high. The results in Figure 4.10 show that the stability index of both supernatant and precipitate-containing solutions is about the same throughout the whole [Ca^{2+}] range.

4.5 The Effect of Calcium-SDS and Calcium-SO Precipitates on the Foaming of SDS Solution

The effect of calcium precipitates on foaming of SO/SDS mixtures was further investigated by varying the bottom solution in the Ross-Miles method. The concentration of SDS in the top solution was fixed at 0.01 M which is above the CMC of SDS.

4.5.1 System with calcium bottom solution

In this system, the top solution is 0.01 M SDS solution and the bottom solution is calcium solution The calcium concentration of bottom solution was varied to cover the regions below and above the SDS precipitation phase boundary.

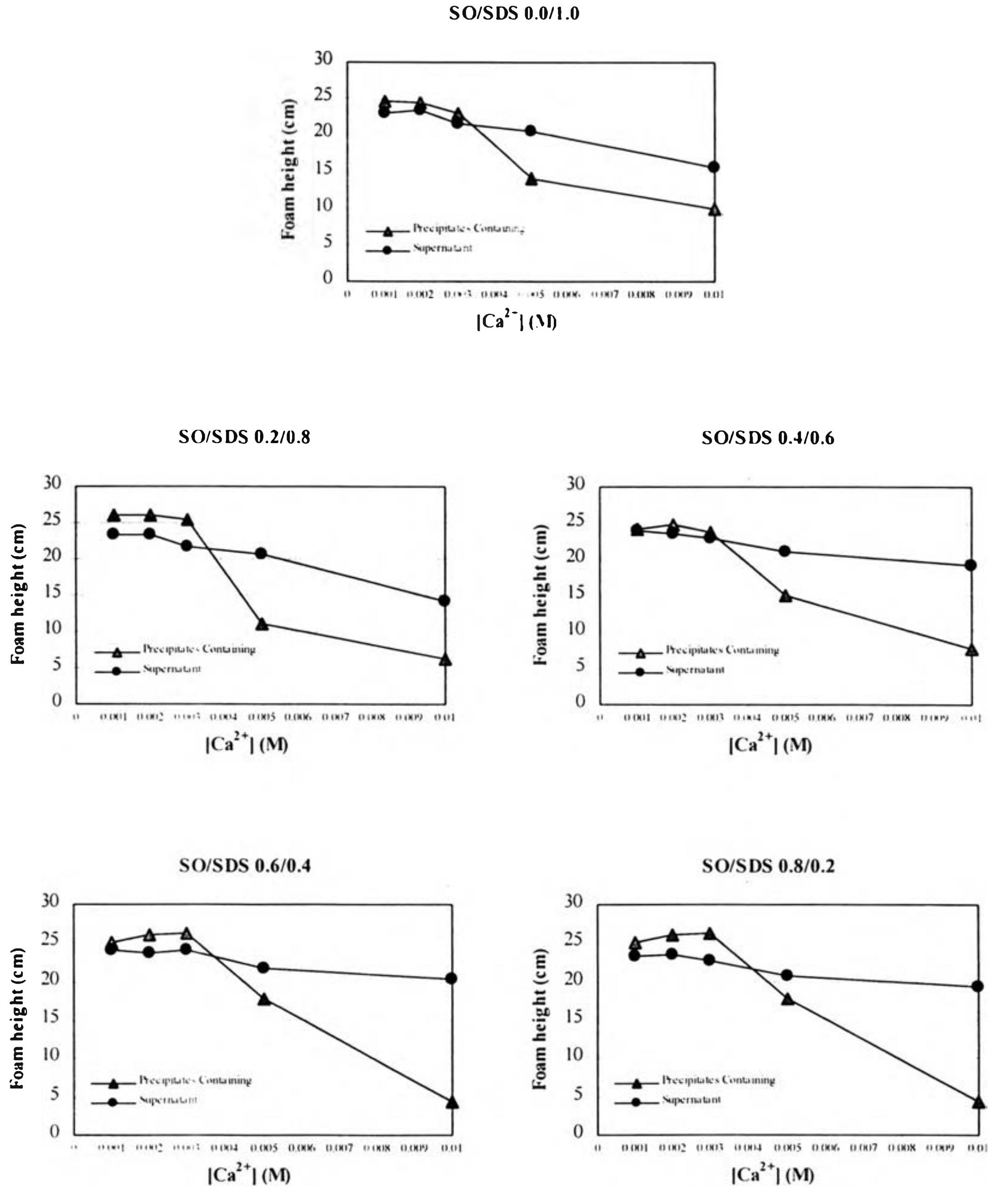

Figure 4.9 Foam height of supernatant and precipitate-containing solutions with varying [SO]/[SDS] ratio and $[Ca^{2+}]$, [SDS] = 0.01 M

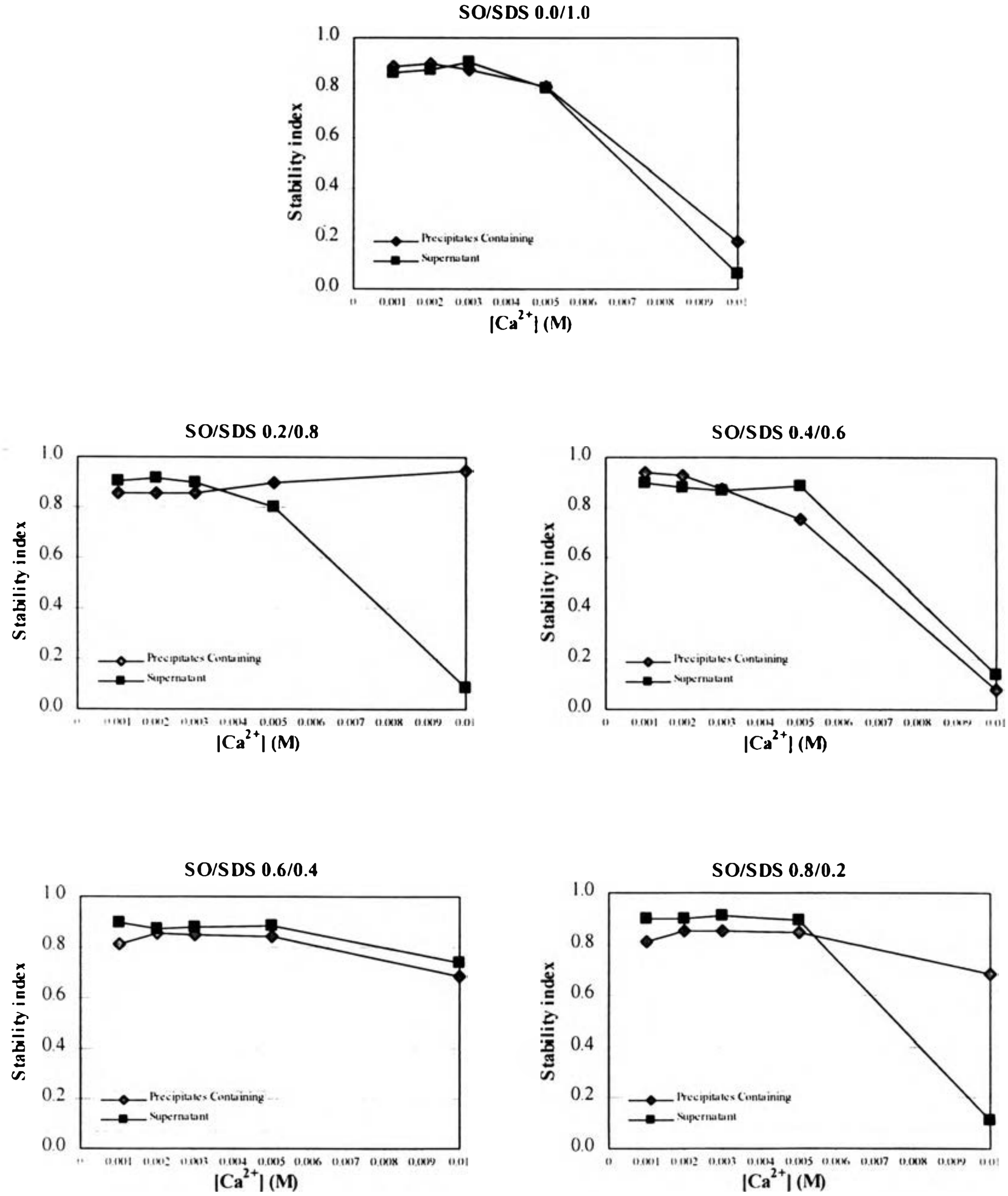

Figure 4.10 Stability index of supernatant and precipitate-containing solutions with varying [SO]/[SDS] ratio and [Ca^{2+}], [SDS] = 0.01 M

Figure 4.11 shows the results of the system where the top solution is 0.01 M SDS solution and the bottom solution is calcium solution with concentration varied from 0 to 0.01 M. Foamability and foam stability decrease sharply as calcium concentration increases from 0 to 0.001 M and level off after that.

4.5.2 System with SDS/calcium bottom solution

In this system, the top solution is 0.01 M SDS solution and the bottom solution is the mixture of 0.01 M SDS solution and calcium solution. The calcium concentration of bottom solution was varied to cover the regions below and above the SDS precipitation phase boundary.

The results in Figure 4.12 show that foamability and foam stability decrease sharply as calcium concentration increases from 0 to 0.001 M and level off after that.

4.5.3 System with SO/calcium bottom mixture

In this system, the top solution is 0.01 M SDS solution and the bottom solution is the mixture of 0.01 M SO solution and calcium solution. The calcium concentration of bottom solution was varied to cover the regions below and above the SO/SDS precipitation phase boundary.

The results in Figure 4.13 show that foamability and foam stability of the mixture solution decrease as calcium concentration increases though at a slower rate than in the above two cases. This is because the presence of 0.01 M SO in the bottom solution helps to raise the total concentration of surfactants in the final solution and so the foamability shows higher tolerance to the presence of calcium.

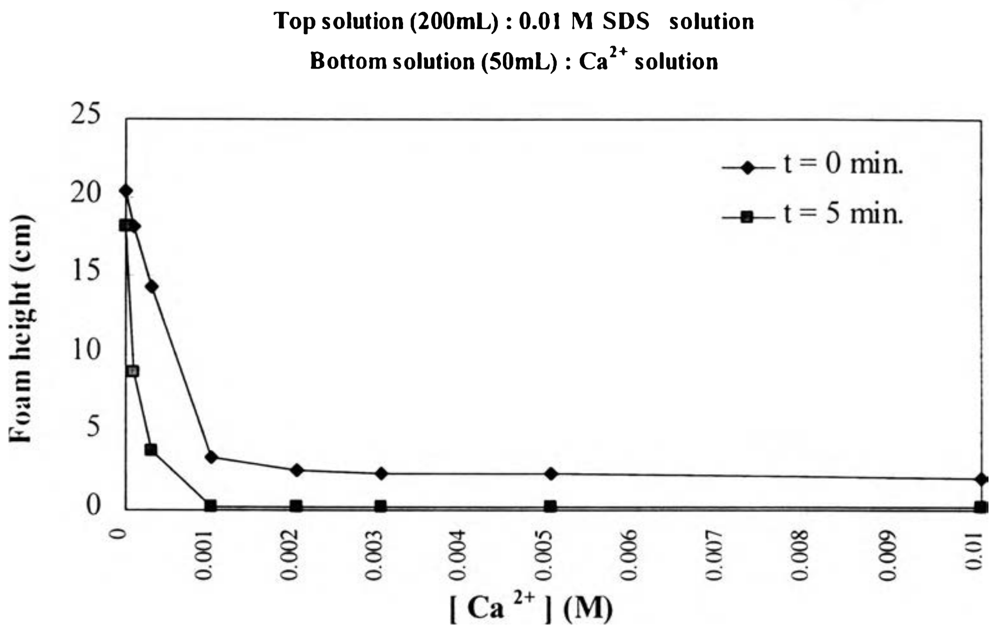

Figure 4.11 Foam height of system with SDS top solution and calcium chloride bottom solution

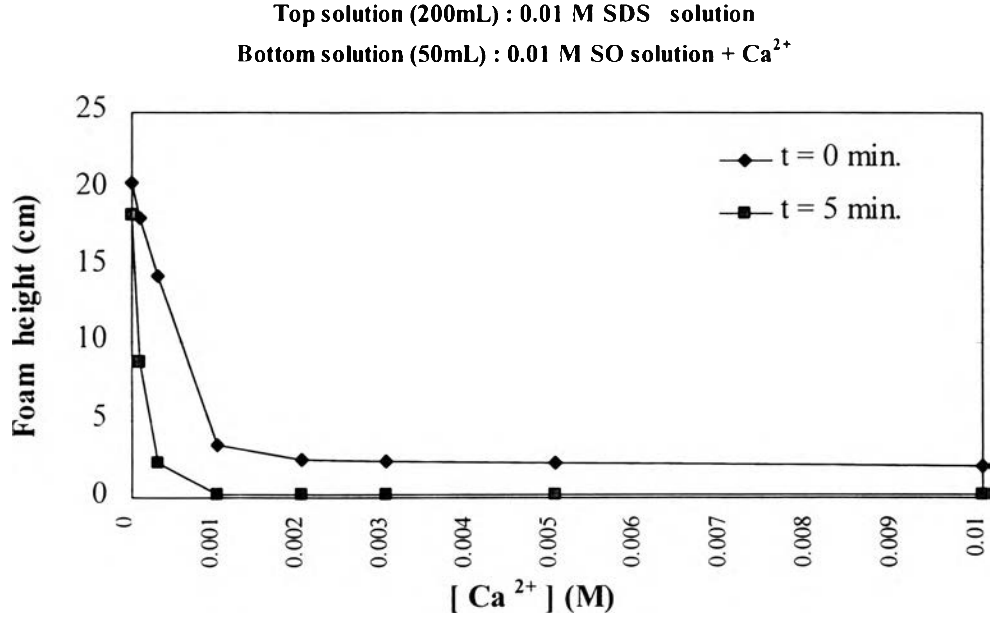

Figure 4.12 Foam height of system with SDS top solution and SDS/calcium chloride bottom solution

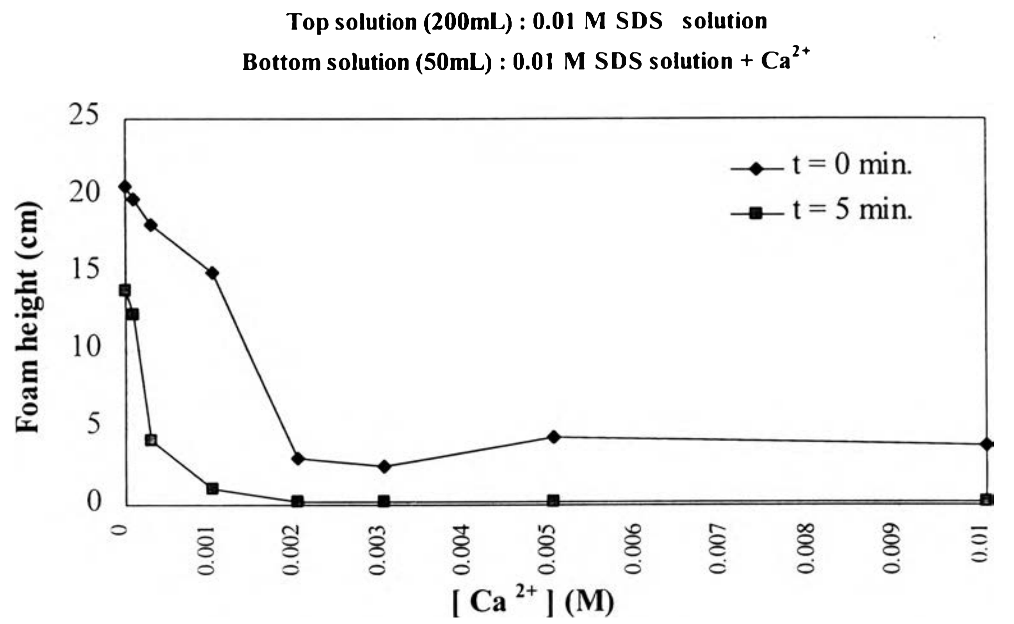

Figure 4.13 Foam height of system with SDS top solution and SO/calcium chloride bottom solution