CHAPTER IV
RESULTS AND DISCUSSION

4.1 Cloud-Point Determination

As in figure 4.1, shows the cloud point of different mixed surfactant systems as a function of the weight fraction of MES. For any given mixed surfactant system, the cloud point tended to increase slightly with increasing MES weight fraction and reached a maximum at around a MES weight fraction of 0.7. With increasing EO group of AE, the cloud point increased significantly. Since the cloud point of both systems of MES:AE7 and MES:AE9 were found higher than room temperature of 25-27° C, then, these two systems were selected for further investigation because in practical, detergents are mostly used at room temperature, so it should be in homogeneous phase for convenient usage.

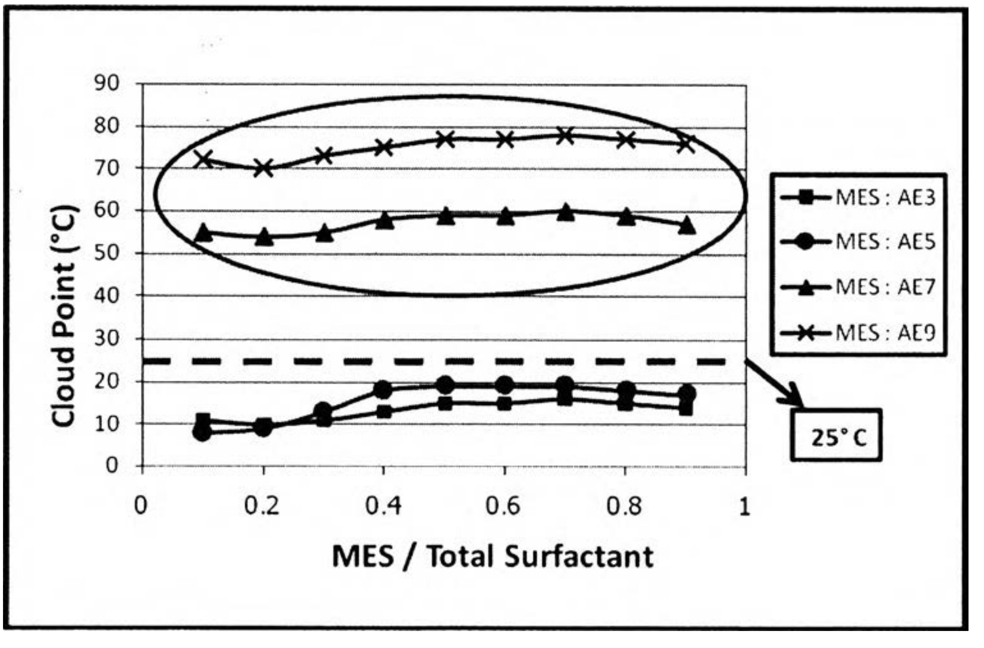

Figure 4.1 Cloud points of mixed surfactants at different MES weight ratio.

4.2 CMC Results

In this research, the CMC value of MES: AE7 and MES: AE9 at different weight ratio were measured. Figure 4.2 and 4.3 show the plots of surface tension and equilibrium total surfactant concentration of the systems of MES: AE7 and MES: AE9 at a weight ratio of 1:9. The CMC value of the MES: AE7 was found at 33 µmol/L which is slightly lower than that of the MES: AE9 which was at 36.3 µmol/L. The lower the CMC value, the lower concentration to form micelle. A system has a lower CMC value indicates to provide a higher micelle concentration and should provide a better oily soil removal. Hence, the mixed surfactant system of MES: AE7 at a weight ratio of 1 to 9 was selected for the detergency experiments. For the other CMC plots were showed in the appendix A.

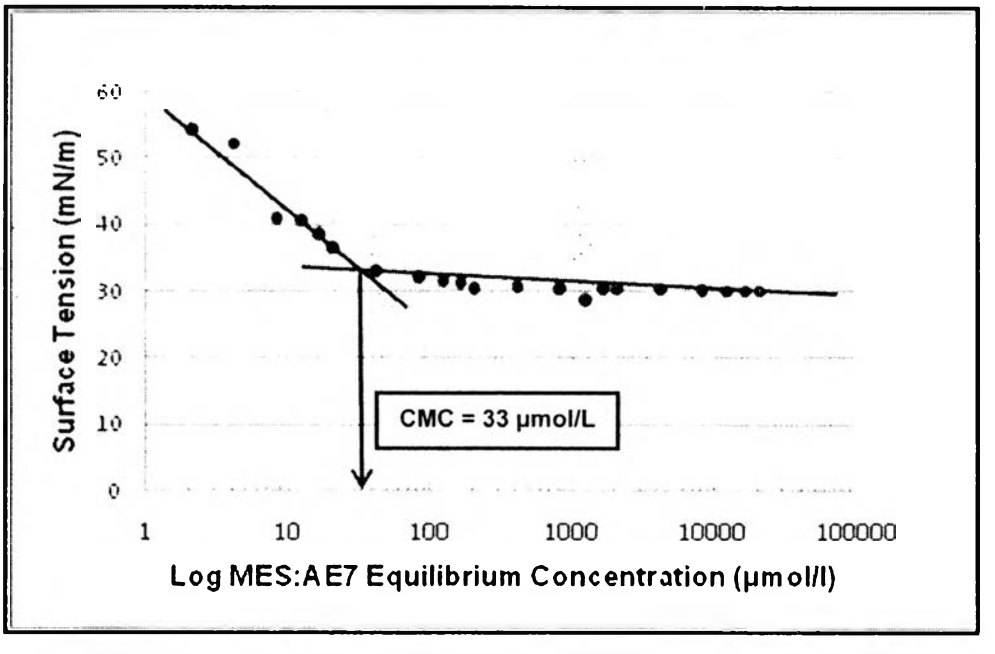

Figure 4.2 Surface tension isotherm of MES: AE7 at weight ratio of 1:9 and 30°C.

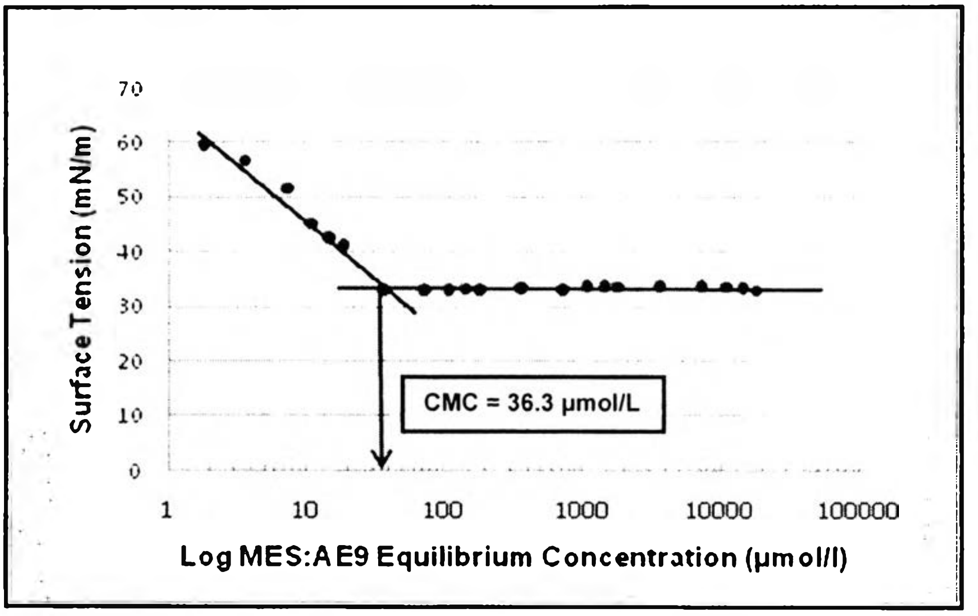

Figure 4.3 Surface tension isotherm of MES: AE7 at weight ratio of 1:9 and 30°C.

Although the selected mixed surfactant system of MES: AE7 (1:9) also consisted of anionic surfactant, but it was not concerned for krafft point determination which is the property of anionic surfactant because it had only one ratio of this mixed surfactant system. So it was not affected that much.

4.3 Detergency Performance Tests

Detergency performance of mixed soil removal can be determined by 3 parameters; %detergency, the amount of oily and particulate soil removal, as well as the amount of removed soil re-deposition on fabric.

4.3.1 Detergency Performance of Oily Soil Removal

According to the cloud point and CMC study, the formulation of MES: AE7 (1:9) was selected for detergency study because of the minimum surface tension. Figure 4.4 shows the % detergency as a function of total surfactant concentration. Under the study conditions with the selected formulation (1:9 of MES: AE7), % detergency increased with increasing of the total surfactant concentration until it reached the plateau at around 0.3% total surfactant concentration (0.03% MES:

0.27% AE7) for 2 types of fabrics. At this concentration, the maximum % detergency of oily soil was given at 68.5% and 60.4% on the cotton and polyester, respectively.

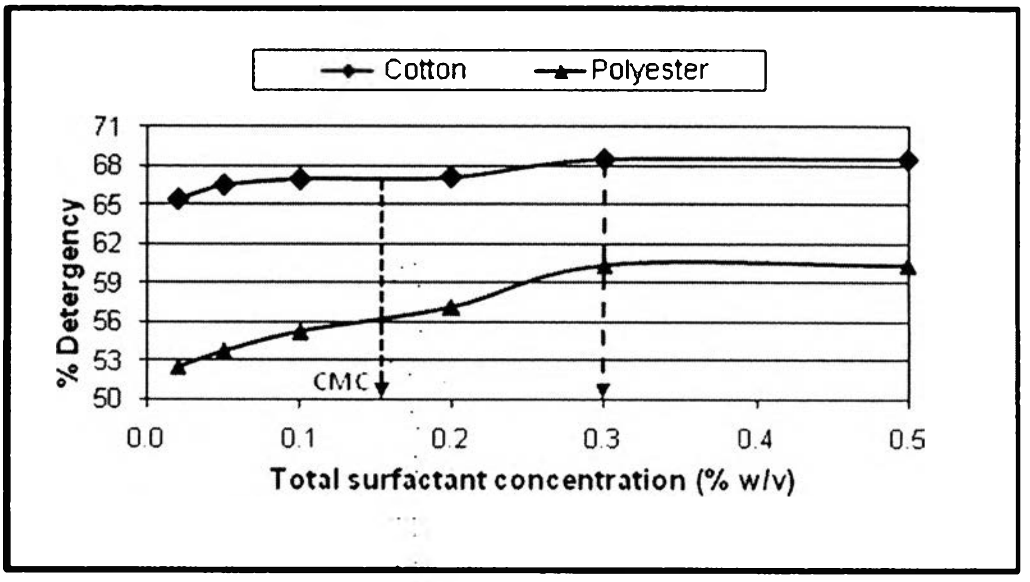

Figure 4.4 %detergency on both test fabrics at different total concentrations of the selected formulation(1:9 of MES: AE7) at 30°C.

The efficiency of oily soil removal can be also determined from the amount of attached oily soil residue on the fabric after washing process. The various total mixed surfactant concentration of MES: AE7 from 0.02% to 0.5% were used in washing experiment to indicate the maximum percentage of oily soil. From figure 4.5, the oil removal efficiency increases with increasing total surfactant concentration and reaches a maximum of 72.5 and 64.7% for the pure cotton and the pure polyester fabrics, respectively. The results can be explained that an increase in total surfactant concentration directly increases the micelle concentration, leading to higher oil solubilization. For any given total surfactant concentration, the cotton showed a higher oil removal as compared to the polyester because the high hydrophobicity of the polyester surface has a stronger bond with the attached oil, leading to being removed much more difficultly as compared to that from the pure cotton fabric.

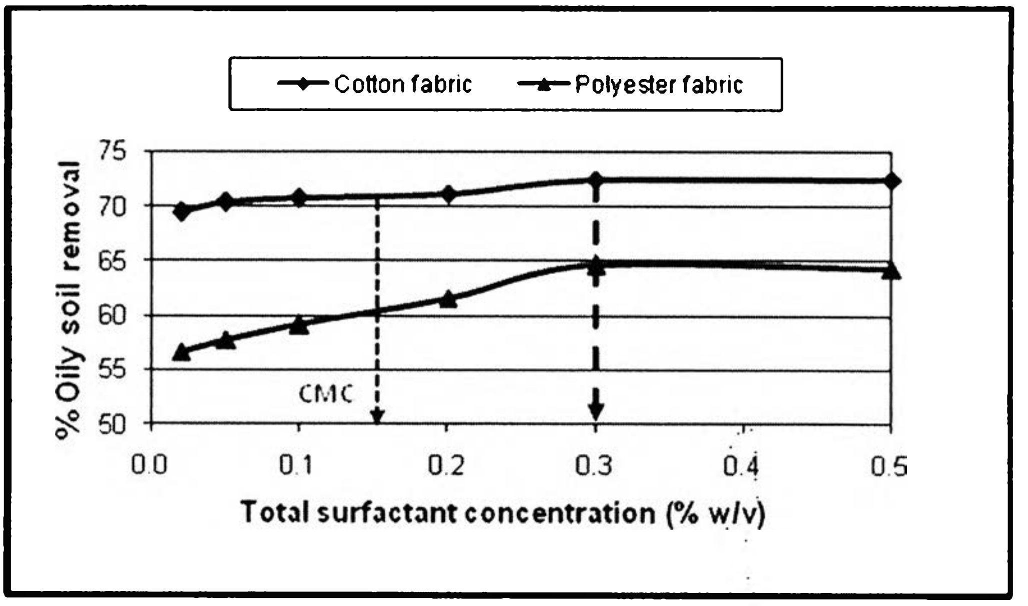

Figure 4.5 Effect of total surfactant concentration on oily soil removal from both test fabrics using the selected formulation(1:9 of MES: AE7) at 30°C.

4.3.1.1 Effect of The Test Fabrics and % Oily Soil Removal

Figure 4.6 shows the oily soil removal as a function of test fabrics. The oily soil can be removed easily from the cotton than the polyester because the hydrophobic oil tends to adhere strongly on the non-polar substrate or the polyester. So, the oily soil is easier to remove from the cotton than the polyester.

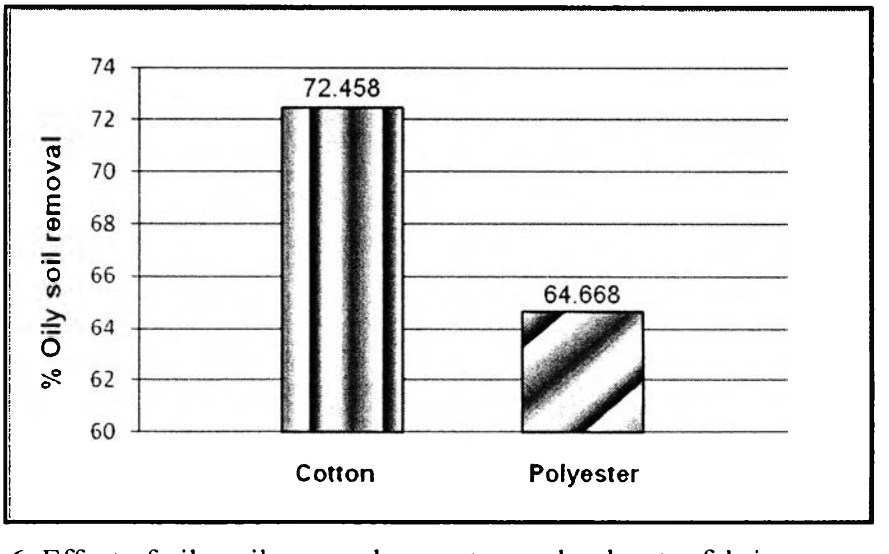

Figure 4.6 Effect of oily soil removal on cotton and polyester fabrics.

4.3.1.2 Effect of Single Surfactant and Mixed Surfactant System for Oily Soil Removal

As mentioned earlier that this study used mixed surfactant, 1:9 of MES: AE7 for detergency performance experiment because mixed surfactant system is believed to improve the detergency performance better than single surfactant system as reported by Tongcumpou *et al.*, 2003.

Figure 4.7 and 4.8 show the % oily soil removal as a function of different surfactant systems on the cotton and the polyester, respectively. Two single surfactant systems: pure AE7 and pure MES and a mixed surfactant system of 1:9 of MES: AE7 at 0.3% total surfactant concentrations and 30°C were used to observe the % oily soil removal on both test fabrics. For the cotton, the selected formulation, 1:9 of MES: AE7 gives the maximum oily soil removal at 72.46% which is higher than that of the other two single surfactant systems, pure AE7 and pure MES that give 67.76% and 65.99%, respectively. In case of the polyester, mixed surfactant system also holds the highest % oily soil removal at 64.69% when compared with the other two single surfactant systems.

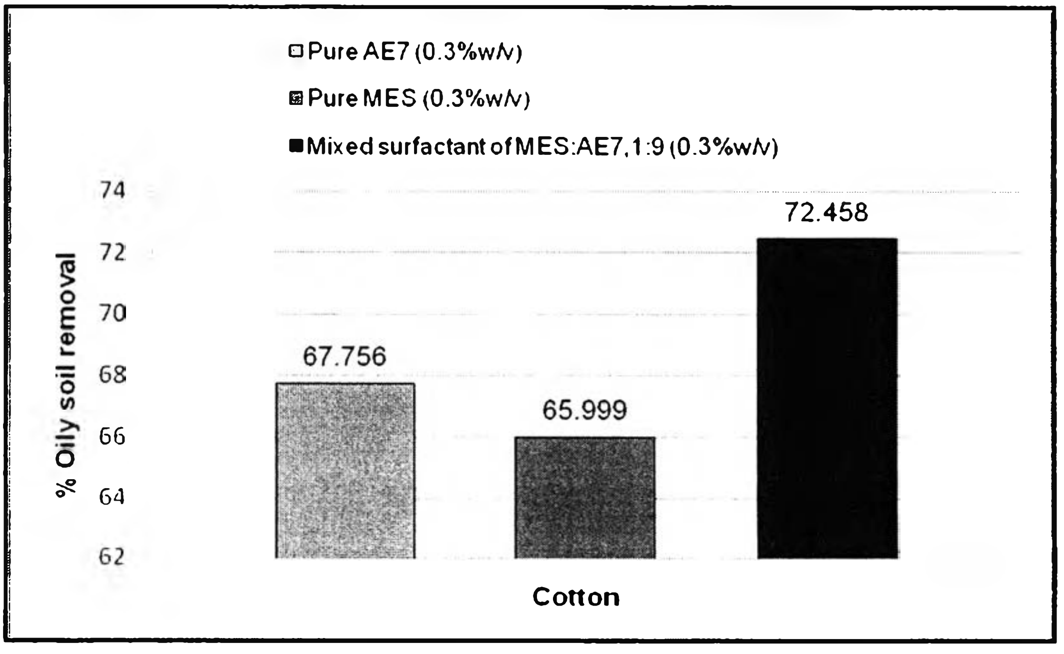

Figure 4.7 Oily soil removal at different surfactant systems on cotton fabric.

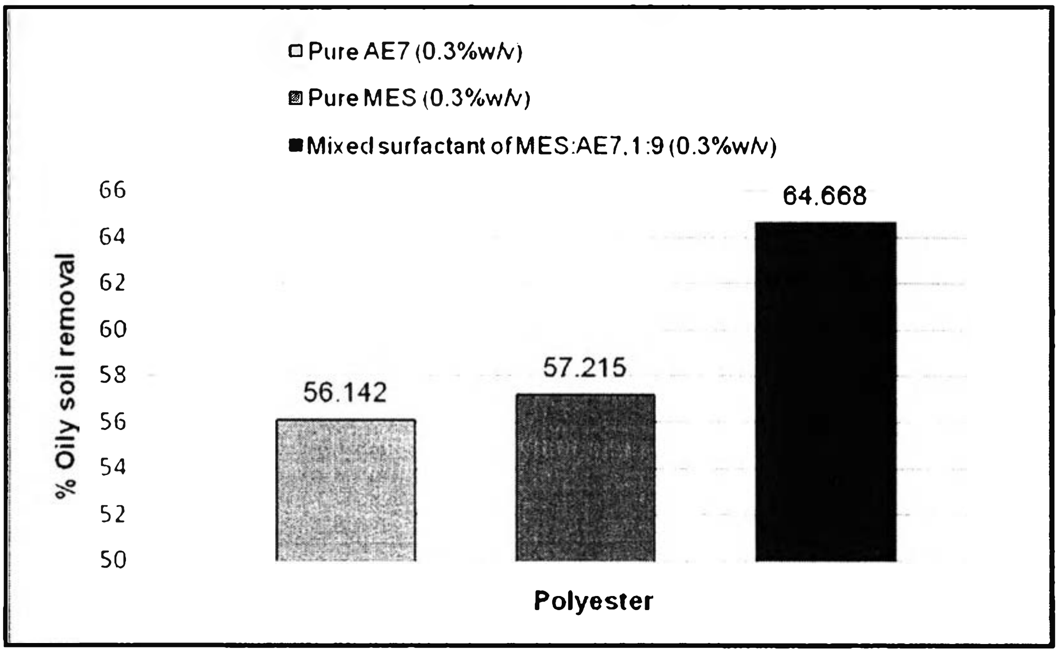

Figure 4.8 Oily soil removal at different surfactant systems on polyester fabric.

4.3.1.3 Effect of Oily Soil Re-deposition as a Function of Total Surfactant Concentration

Figure 4.9 shows the re-deposition of oily soil on both test fabrics as a function of total surfactant concentration using the selected formulation. The re-deposition of oily soil decreased slightly with increasing total surfactant concentration. Interestingly, for any given total surfactant concentration, the oily re-deposition was found much higher on the polyester than that on the cotton. This is because of the hydrophobicity of the polyester surface. This is a reason to explain why the oil removal for the cotton was found to be much higher than the polyester.

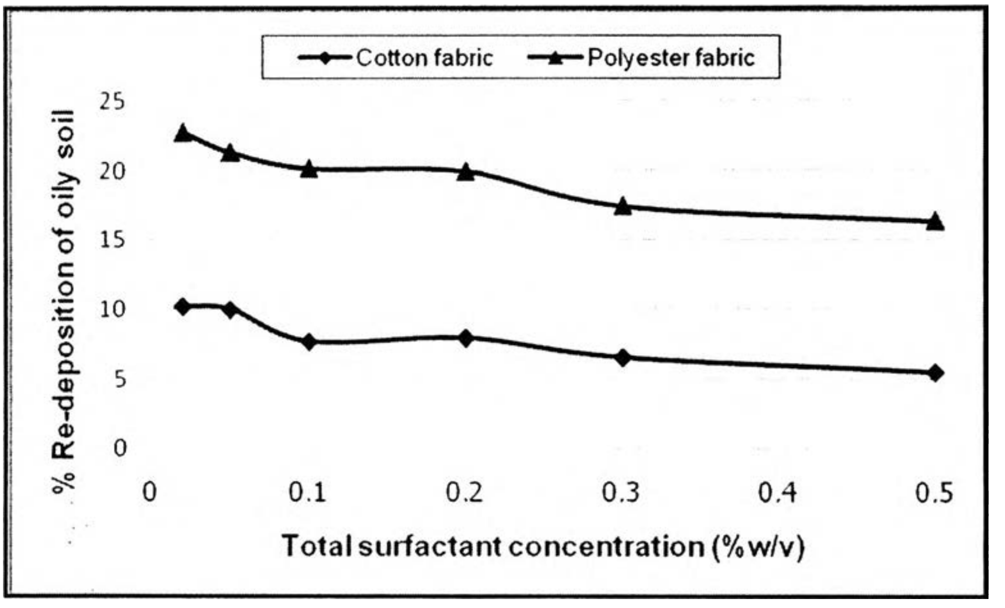

Figure 4.9 Re-deposition of oily soil as a function of total surfactant concentration on both test fabrics using the selected formulation (1:9 MES: AE7) and 30° C.

4.3.1.4 Comparisons of % Oily Soil Removal between The Selected Formulation and The Commercial Detergent on Test Fabrics

Figure 4.10 and 4.11 show the detergency performance of the commercial detergent in terms of maximum oily soil removal on both test fabrics at the same optimum surfactant concentration of 0.3%. In comparisons between the two test fabrics, the oily soil removal from the cotton was found to higher than the polyester. The results can be explained by the fact that the cotton surface is hydrophilic but the polyester surface is hydrophobic. When compared the results of the selected formulation with those of the commercial detergent, for any given test fabric, the selected formulation could provide a much higher oily soil removal. The results can be explained in that the selected formulation contained a significant fraction of the AE, nonionic surfactant which is good for oily soil detergency.

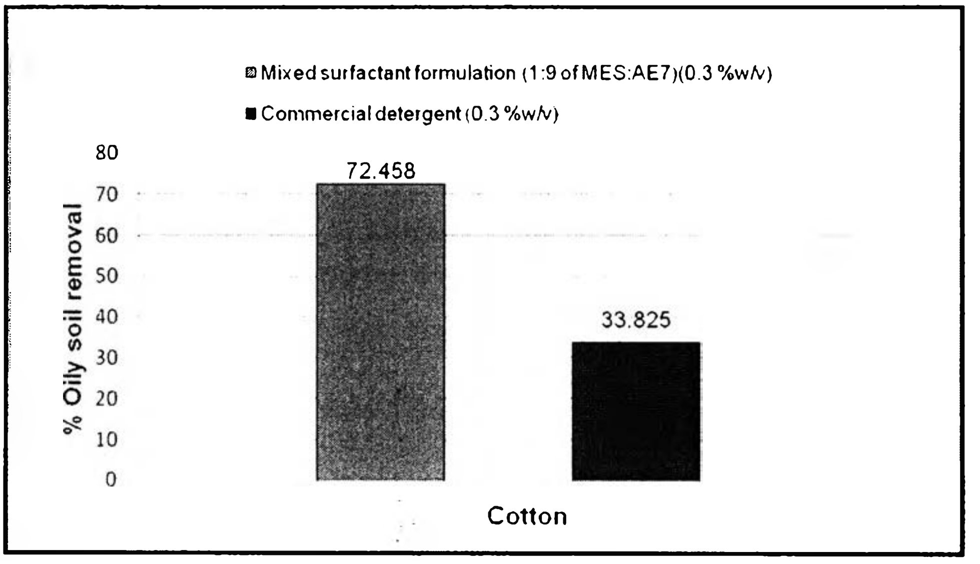

Figure 4.10 Oily soil removal of the selected formulation and the commercial detergent (Breeze Excel) at 0.3% and 30°C on cotton fabric.

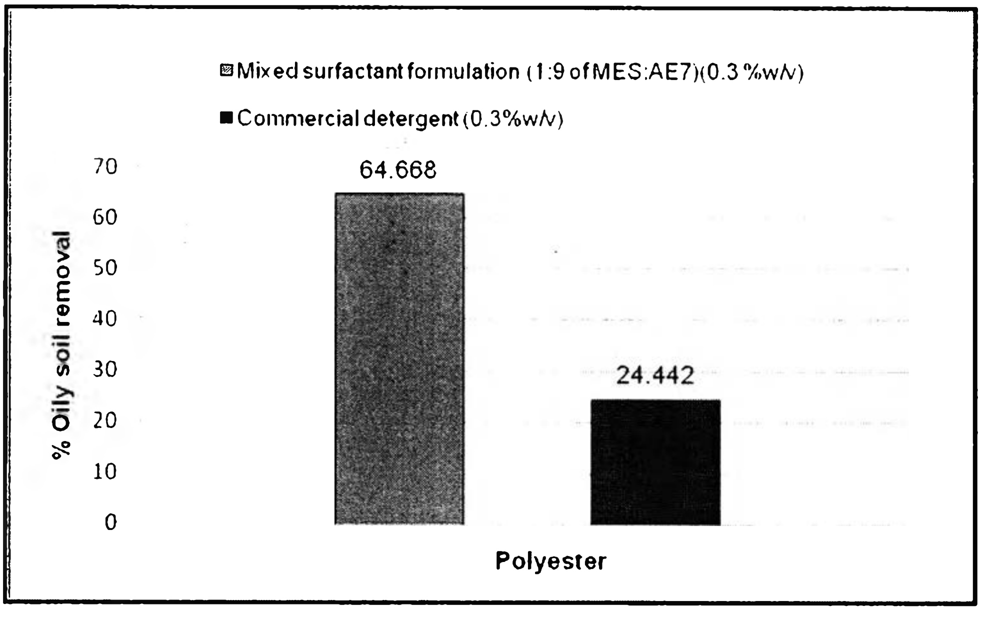

Figure 4.11 Oily soil removal of the selected formulation and the commercial detergent (Breeze Excel) at 0.3% and 30°C on polyester fabric.

4.3.2 Detergency Performance of Particulate Soil Removal

Figure 4.12 shows the effect of total surfactant concentration on the particulate soil removal from both test fabrics using the selected formulation (MES: AE7) at the weight ratio of 1:9. The particulate soil removal increased with increasing total surfactant concentration and reached a maximum at a total surfactant concentration of 0.3% for both test fabrics. The increasing total surfactant concentration simply increases the surfactant adsorption on both surfaces of kaolinite and test fabrics, leading to increasing the repulsion forces between the kaolinite particles and the fabric surfaces. Interestingly, the optimum total surfactant concentrations for both removals of oily and particulate soils were found to be the same. This is because the selected formulation of MES: AE7 at the weight ratio of 1:9 can provide the highest synergistic effect for both highest surfactant adsorption and micelle formation which in turn, leads to both highest removals of oily and particulate soils.

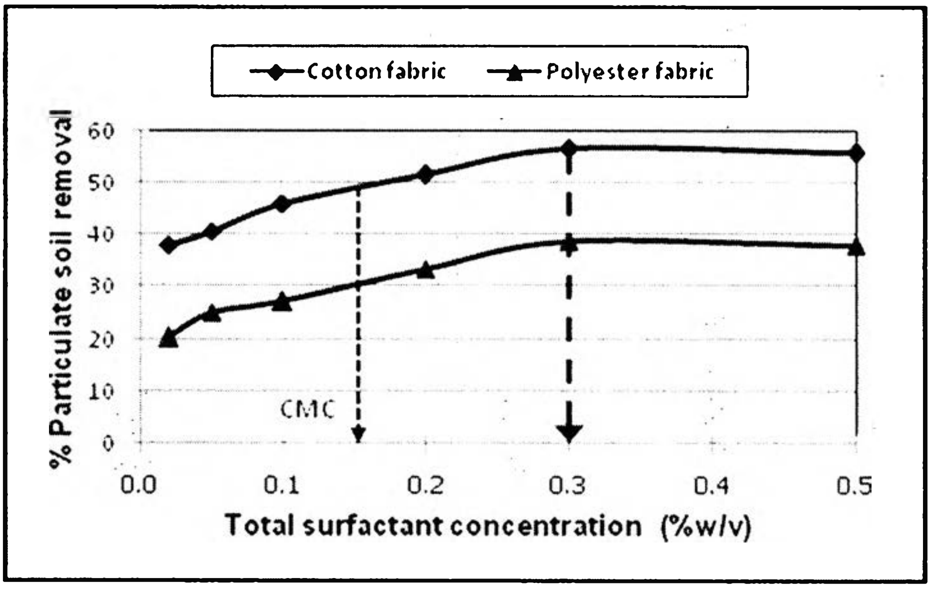

Figure 4.12 Effect of total surfactant concentration on particulate soil removal from both test fabrics using the selected formulation(1:9 of MES: AE7) at 30°C.

4.3.2.1 Effect of The Test Fabrics and % Particulate Soil Removal

From figure 4.13, the cotton shows highly percentage of particulate soil removal than the polyester, because the hydroxyl groups (-OH) in the cotton structure which increased the hydrophilicity and water solubility. The repulsion between the head group of MES adsorption onto the kaolinite surface and the hydrophilic surface (cotton fabric) may also has an effect on these results. Hence, the particulate soil on the cotton was removed more easily than that from the polyester.

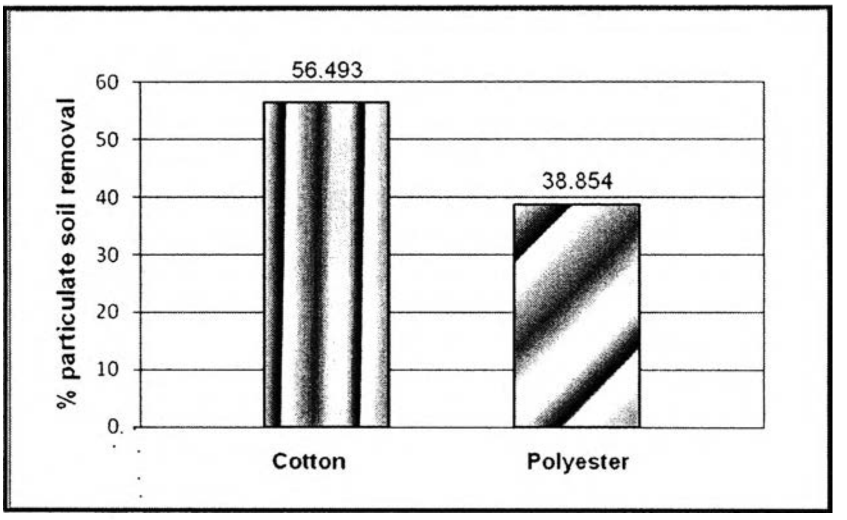

Figure 4.13 The effect of particulate soil removal on cotton and polyester fabrics.

4.3.2.2 Effect of Single Surfactant and Mixed Surfactant System for Particulate Soil Removal

Figure 4.14 and 4.15 show the % particulate soil removal as a function of different surfactant systems at 0.3% total surfactant concentration on the cotton and the polyester, respectively. In comparisons among the three surfactant systems, the mixed surfactant system, 1:9 of MES: AE7 gives the maximum % kaolinite removal at 59.49% which is higher than the other two single surfactant systems, pure AE7 and pure MES. These results show the similar trends as compared to the case of oily soil removal.

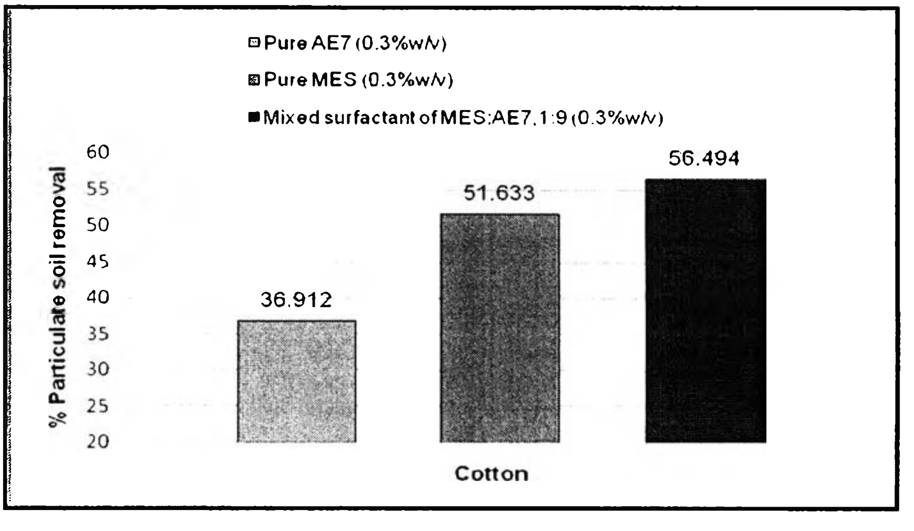

Figure 4.14 Particulate soil removal at different surfactant systems on cotton fabric.

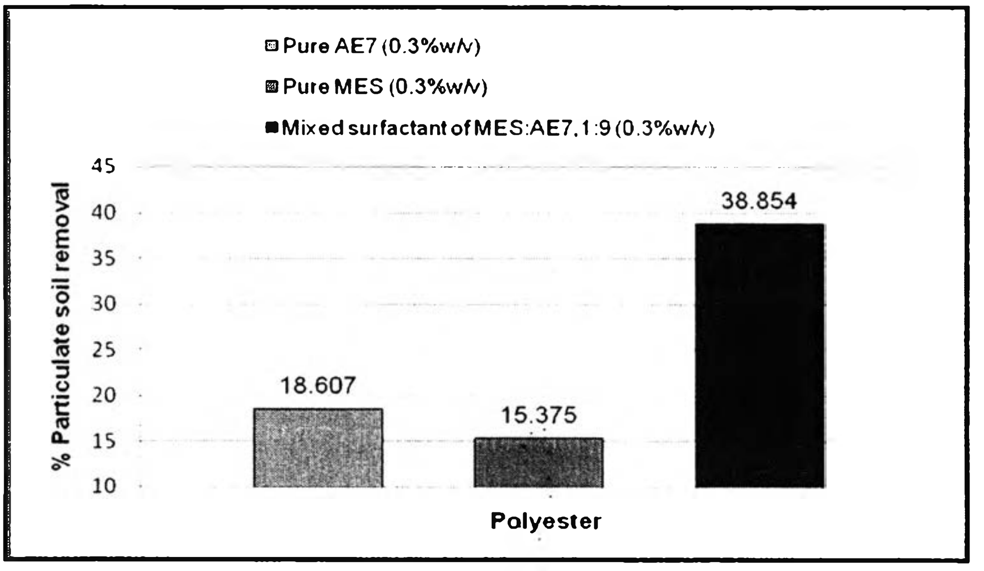

Figure 4.15 Particulate soil removal at different surfactant systems on polyester fabric.

4.3.2.3 Effect of Particulate Soil Re-deposition as a Function of Total Surfactant Concentration

Figure 4.16 shows the re-deposition of particulate soil on both test fabrics as a function of total surfactant concentration using the selected formulation. The effect of fabric hydrophilicity/hydrophobicity was found to be insignificant. The re-deposition of particulate soil decreased significantly with increasing total surfactant concentration but it almost reached a maximum beyond the optimum total surfactant concentration of 0.3%.

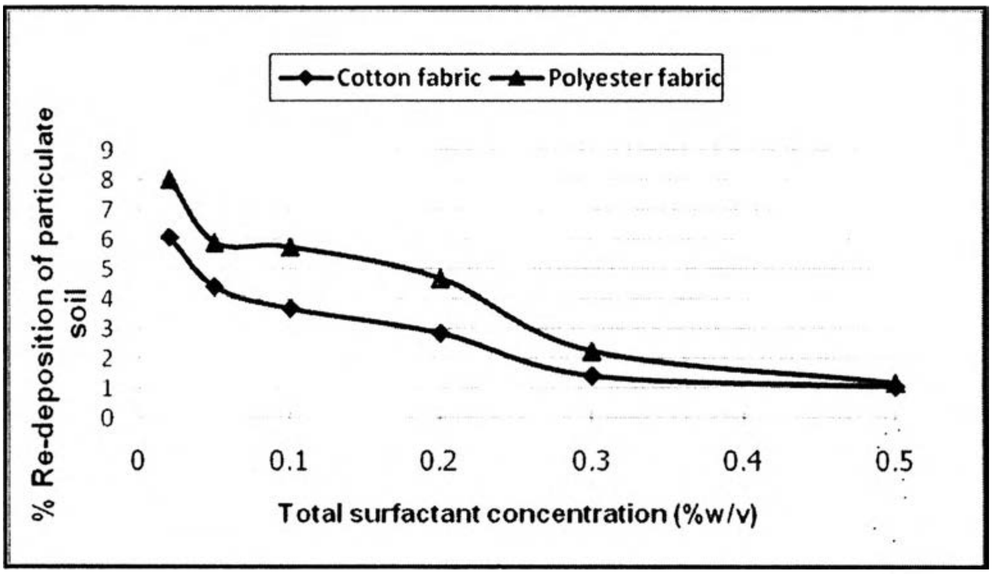

Figure 4.16 Re-deposition of particulate soil as a function of total surfactant concentration on both test fabrics using the selected formulation (1:9 MES: AE7) and 30° C.

4.3.2.4 Comparisons of % Particulate Soil Removal between The Selected Formulation and The Commercial Detergent on Test Fabrics

Figure 4.17 and 4.18 show the detergency performance of the commercial detergent in terms of maximum particulate soil removal from both test fabrics at the same optimum surfactant concentration of 0.3%. For both test fabrics, the particulate soil removal was found much higher in case of using the commercial detergent which had an opposite result from the oily soil case. The results can be explained that in the commercial detergent product contains mostly the anionic surfactant (linear alkylbenzene sulfonate) which is good for particulate soil removal.

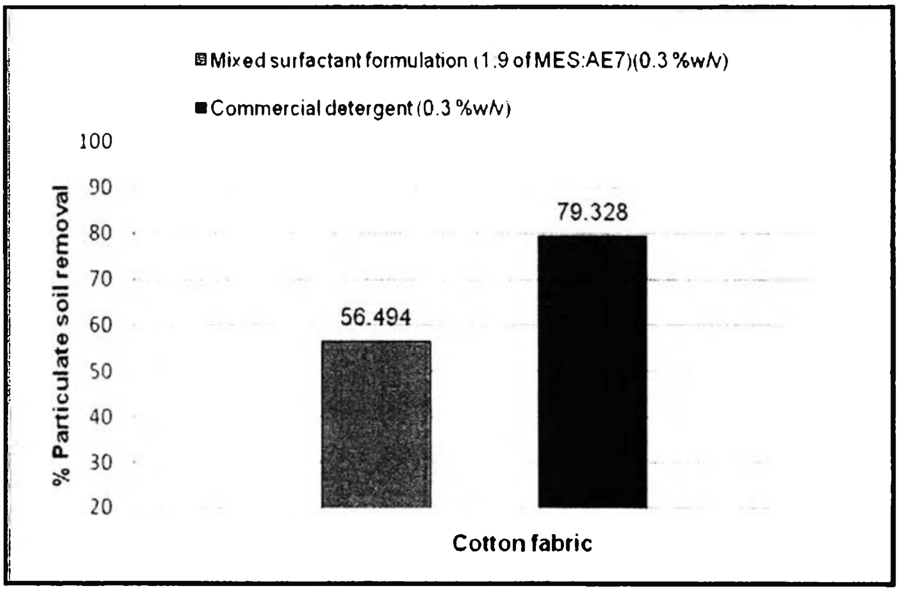

Figure 4.17 Particulate soil removal of the selected formulation and the commercial detergent (Breeze Excel) at 0.3% and 30°C on cotton fabric.

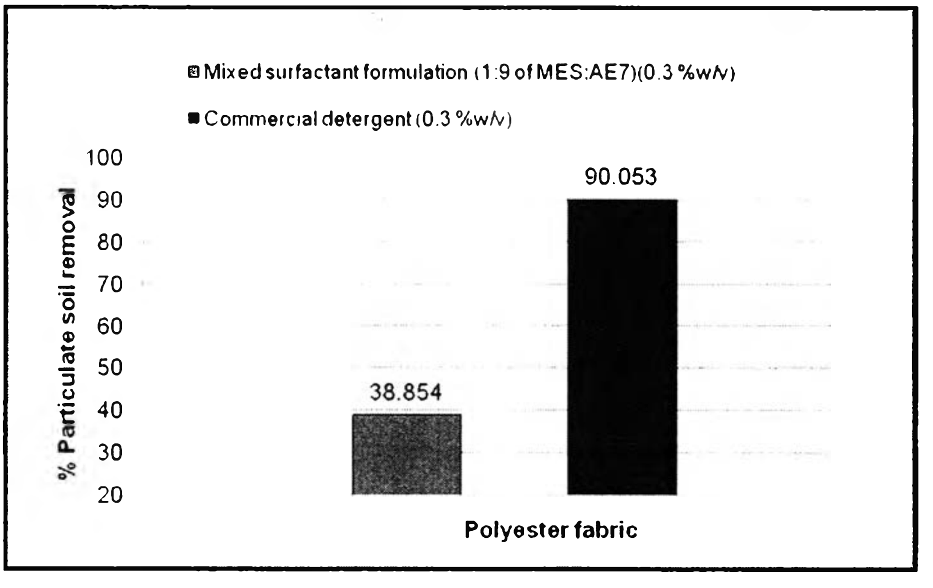

Figure 4.18 Particulate soil removal of the selected formulation and the commercial detergent (Breeze Excel) at 0.3% and 30°C on polyester fabric.

4.3.3 Effect of Detergency in Washing, 1st Rinsing, and 2nd Rinsing Steps

Figure 4.19 and 4.20 show the % cumulative of oily and particulate soil removals in each step of detergency process on both test fabrics using the selected formulation 1:9 of MES: AE7 at 0.3% total surfactant concentration. The result showed that oily and particulate soils were removed in washing step more than that in 1st rinsing, and 2nd rinsing steps on both test fabrics and the % soil removals were insignificant changed in 1st rinsing, and 2nd rinsing steps.

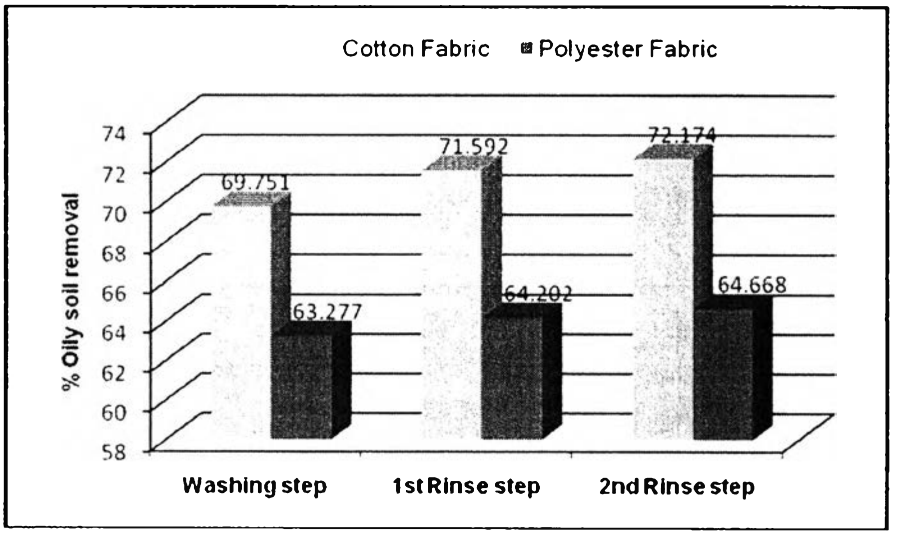

Figure 4.19 Oily soil removal in each detergency step using the selected formulation at 0.3% and 30°C on polyester fabric on cotton and polyester fabrics.

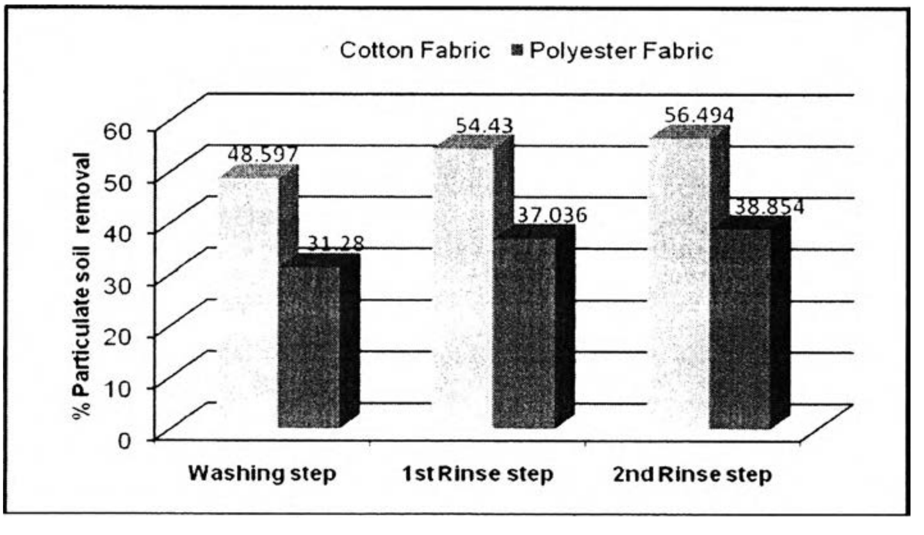

Figure 4.20 Particulate soil removal in each detergency step using the selected formulation at 0.3% and 30°C on polyester fabric on cotton and polyester fabrics.