CHAPTER IV
RESULTS AND DISCUSSION

4.1 Zeta Potential and PZC Results

Figures 1 and 2 show the zeta potential of carbon black in the Triton X-100 and SDS solutions at different concentrations and pH values respectively. The zeta potential of carbon black became more negative with increasing SDS concentration. For any given SDS concentration, the zeta potential of carbon black became more negative with increasing solution pH. The results can be explained in that the negative charge of the head group of SDS adsorbing on the carbon black surface is responsible for the increasing negative charge on the carbon black surface. In contrast, the zeta potential of carbon black in Triton X-100 solution became less negative with increasing Triton X-100 concentration, as shown in Figure 2. The results can be explained in that the Triton X-100 adsorption onto the carbon black can mask the negative charge of the carbon black surface.

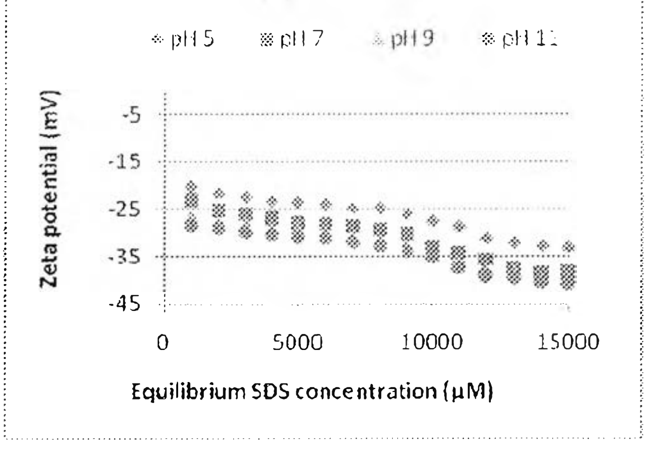

Figure 4.1 Zeta potential of carbon black in SDS solutions at various pH values and 30°C

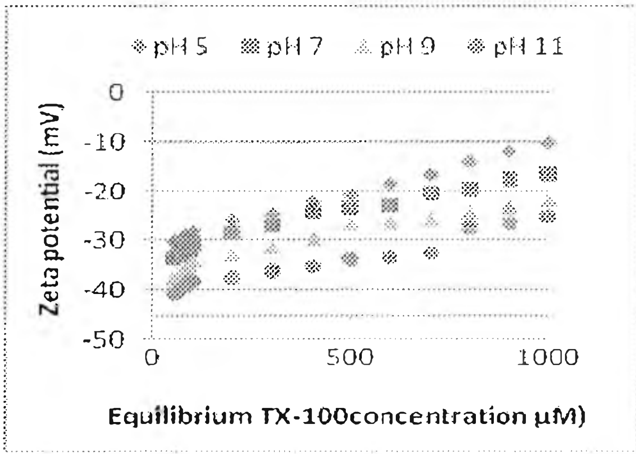

Figure 4.2 Zeta potential of carbon black in Triton-X 100 solution at various pH values and 30°C

Figure 3 shows the zeta potential as a function of equilibrium pH of three fabrics. The PZC is the pH corresponding to the zeta potential equal to zero. From Figure 3, the PZC values are 2.9, 2.3 and 2.5 for the cotton, polyester and polyester/cotton blend, respectively which are in good agreement with previous study [Ana *et al.*, 2005]. In comparisons among three studied fabrics, the polyester fiber exhibited the most negative zeta potential (-69.4 mV), in which the zeta potential of the higher hydrophobic fiber is larger than that of hydrophilic fibers due to hydration capacity. The cotton fiber had the highest zeta potential (-24.5 mV), this fiber is negatively charged due to the presence of hydroxyl and carboxy groups. The functional groups influence the zeta potential, but the fiber swelling has an important role also. The interfibrillar swelling enlarges the surface area, and causes the shift plane into liquid phase lowering the zeta potential [Ana *et al.*, 2005].

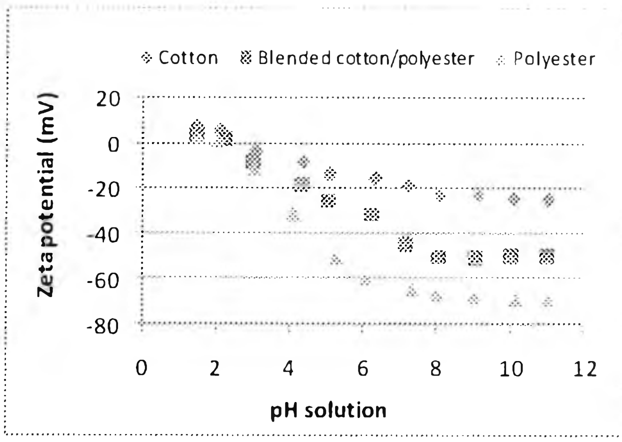

Figure 4.3 Zeta potential of fabrics in deionized water at various pH value

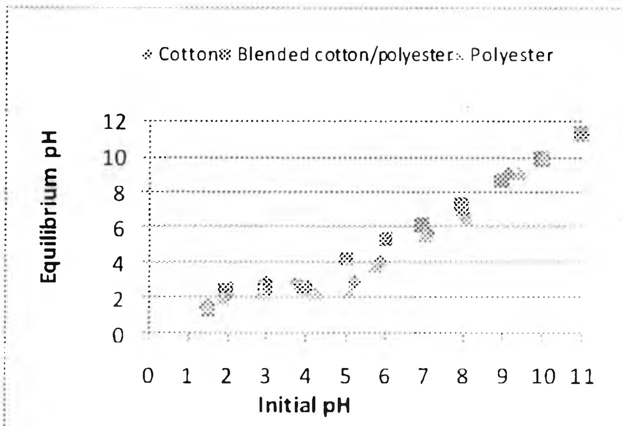

Figure 4.4 The plot of initial pH VS equilibrium pH of different fabrics

4.2 Surfactant Adsorption Isotherm Results

4.2.1 Anionic Surfactant Adsorption Isotherm

Figure 5 shows the adsorption isotherm of SDS on carbon black at different pH values. The maximum surfactant adsorption of 2.69 μmole/m^2 when the SDS concentration was greater than the CMC of SDS, which is 8,300 μM (Mukerjee and Mysel,.) An increase in solution pH decreased slightly the SDS adsorption onto the carbon black because the surface charge of the carbon black become more negative, leading to decreasing the adsorption of SDS which is an anionic surfactant.

However the effect of pH on the SDS adsorption onto carbon black is insignificant. This is because the surface of carbon black is very hydrophobic.

Figure 6 shows the SDS adsorption onto the cotton fabric at different solution pH values. In a comparison between the SDS adsorption on carbon black and the cotton fabric, the effect of solution pH in the cotton fabric was much higher than that on carbon black. The explanation is that the SDS adsorption difference on these two surfaces as the head down with the hydrophilic cotton surface while tail down with the hydrophobic surface of carbon black. Similarly, the SDS adsorption onto the cotton fabric reached the maximum when SDS concentration was greater than the CMC.

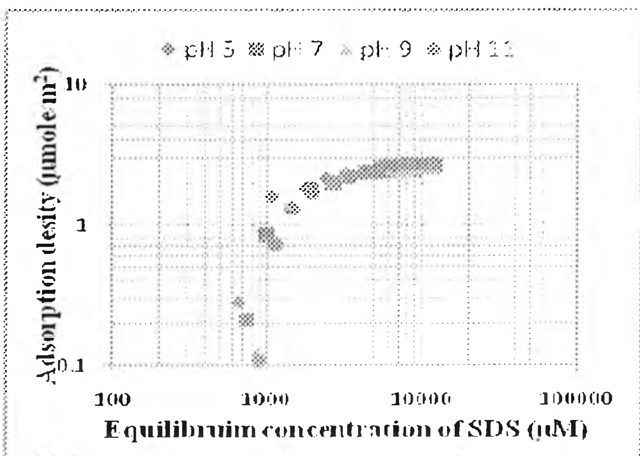

Figure 4.5 Adsorption Isotherm of SDS on carbon black at 30°C and various pH value

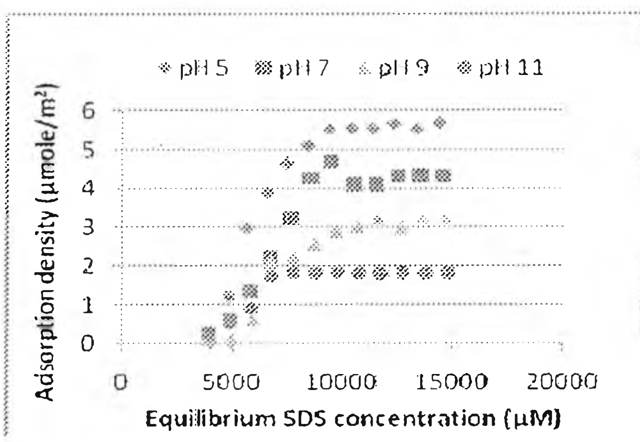

Figure 4.6 Adsorption Isotherm of SDS on cotton fabric at 30°C and various pH values

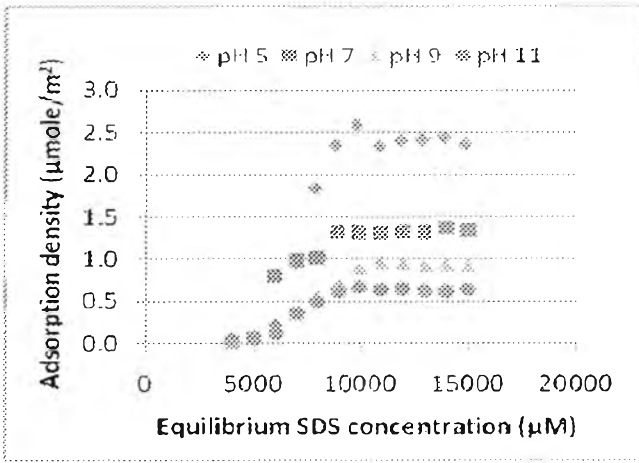

Figure 4.7 Adsorption Isotherm of SDS on polyester/cotton blend at 30□C and various pH values

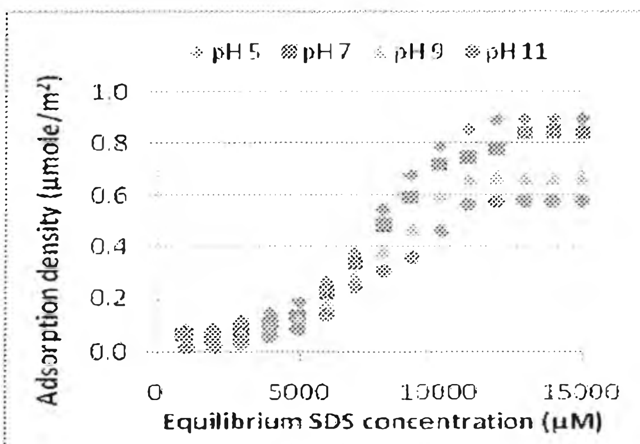

Figure 4.8 Adsorption isotherm of SDS on polyester fabric at 30°C and variuos pH values

Figures 7 and 8 show the SDS adsorption on the polyester/cotton blend and the polyester, respectively. In comparisons among the three fabrics, the degree of SDS adsorption was found to be cotton > polyester/cotton blend > polyester which correspond to the degree of hydrophilicity of the studies fabric: cotton > polyester/cotton blend > polyester.

4.2.2 Nonionic Surfactant Adsorption Isotherms

The adsorption isotherm of Triton X-100 on carbon black at various pH values is shown in Figure 9. Surfactant adsorption was saturated at the CMC (300 μm) of Triton X-100 which is in good agreement with literature [Gonzalez et al., 2001]. From Figure 9, the Triton X-100 adsorption on carbon black increases with increasing solution pH. The maximum amount of Triton X-100 surfactant adsorbed per unit area of carbon black of 0.08 μmole/m^2 was lower than the maximum adsorption density of SDS.

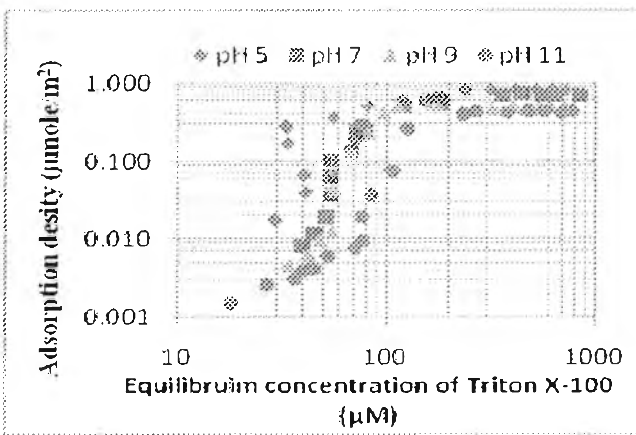

Figure 4.9 Adsorption Isotherm of Triton X -100 on carbon black at 30°C and various pH values

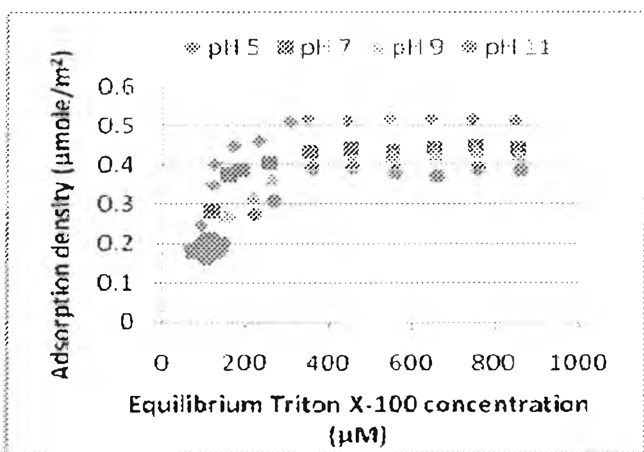

Figure 4.10 Adsorption Isotherm of Triton X-100 on cotton fabric at 30°C and various pH values

Figures 10, 11 and 12 show the Triton X-100 adsorption isotherm on the three fabrics. The Triton X-100 adsorption on these three fabrics showed the similar trends as compared to the case of SDS. Interestingly, the effect of solution pH on the SDS adsorption on any fabric was found to be higher than Triton X-100. For any given type of fabric and solution pH, the maximum adsorption of SDS was found to be significantly higher than that of Triton X-100.

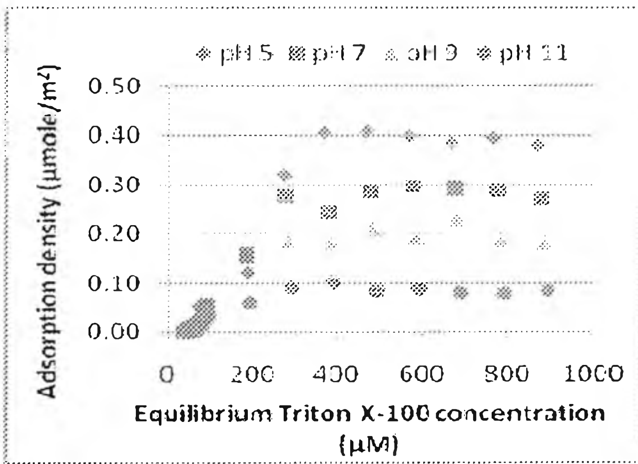

Figure 4.11 Adsorption Isotherm of Triton X-100 on polyester/cotton blend fabric at 30°C and various pH values

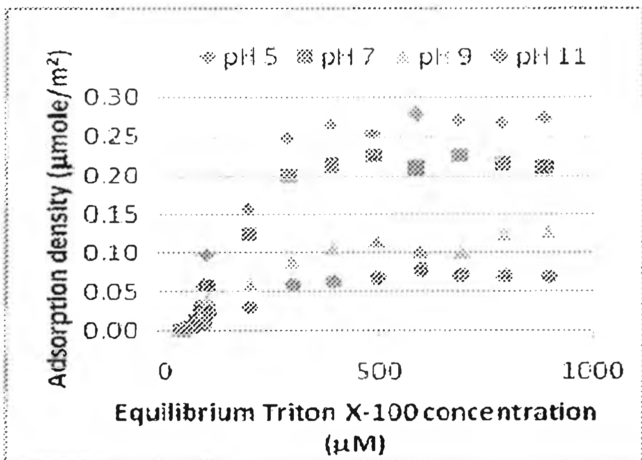

Figure 4.12 Adsorption Isotherm of Triton X- 100 on polyester fabric at 30°C and various pH values

4.3 Detergency Performance

4.3.1 Detergency Performance of Anionic Surfactant

The detergency performance of carbon black removal in terms of %detergency as a function of SDS concentration on the three studied fabrics is shown in Figures 13, 14 and 15. For any given type of the testing fabric and solution pH value, the detergency performance increased with increasing SDS concentration and leveled off when the SDS concentration exceeded 0.9%w/v. An increase in solution pH increased slightly detergency performance for the cotton fabric and polyester/cotton blend but the effect of solution pH was quite significant for the polyester fabric. In a comparison among the three fabrics, the highest detergency performance was found to be 71%, 69% and 66% for the polyester, polyester/cotton blend, and the cotton, respectively. The results can be explained in that the polyester fabric has the highest negative charge, leading to the highest repulsion force between the head group of SDS adsorption onto the carbon black surface and the negative-charged surface of the polyester fabric.

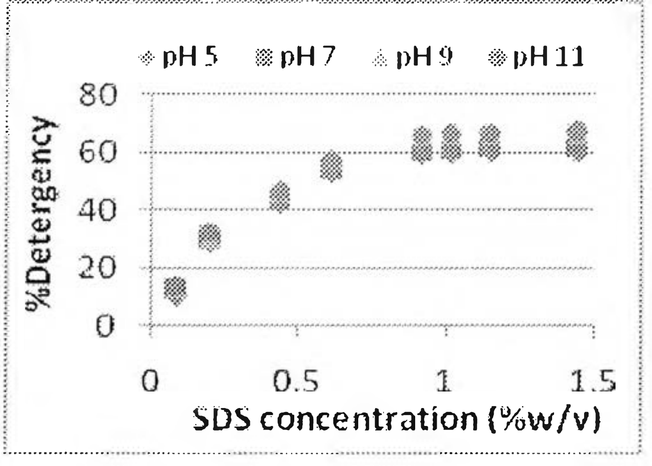

Figure 4.13 %Detergency on cotton fabric at different SDS concentrations and solution pH values

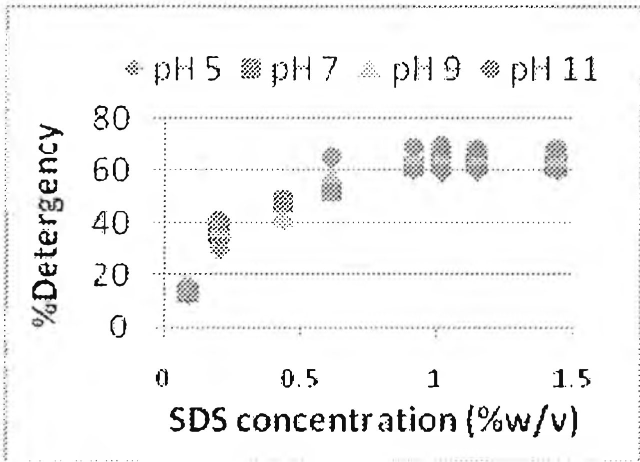

Figure 4.14 %Detergency on cotton/ polyester blend fabric at different SDS concentrations and solution pH values

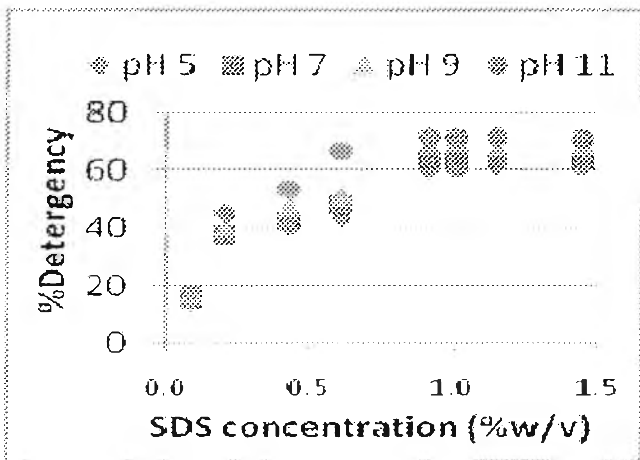

Figure 4.15 %Detergency on polyester fabric at different SDS concentrations and solution pH values

4.3.2 Detergency Performance of Nonionic Surfactant

Figures 16, 17 and 18 show the effect of the concentration and pH value of TritonX-100 solution on the detergency performance of the three studied fabrics. The Triton X-100 system showed the similar trend as the SDS system in which the detergency performance increased with increasing Triton X-100 concentration and solution pH. The same explaination can be used in the case of Triton X-100. Since the Triton X-100 have no charge on the molecular structure, there is lower zeta potential of solids present in the aqueous solution than SDS molecule as shown in Figure 2. Thereby there are lower repulsions of Triton X-100 molecule and soil including that between soils and fabric than repulsion of SDS molecule so the anionic surfactant shows higher %detergency than nonionic surfactant. However the use of higher Triton X-100 concentrations causes the steric effect and higher repulsion force between ethylene group of Triton X-100 and carbon black surface including fabric surface thus carbon black removal can be achieved. The %detergency of the polyester, polyester/cotton blend, and the cotton fabrics are 62%, 57% and 45%, respectively. The highest %detergency can be found on the polyester fabric.

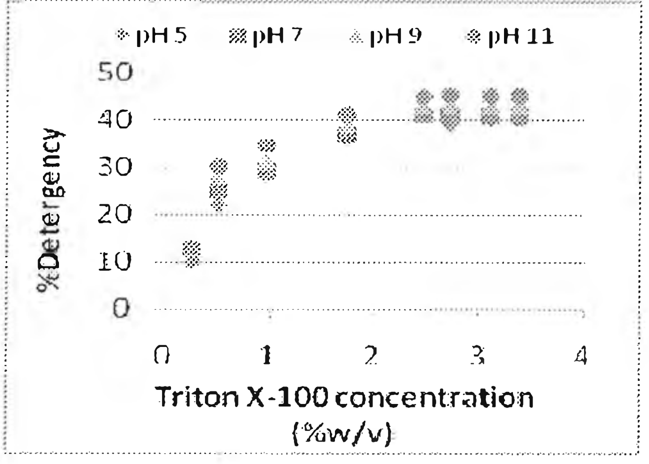

Figure 4.16 %Detergency on cotton fabric at different Triton X-100 concentrations and solution pH values

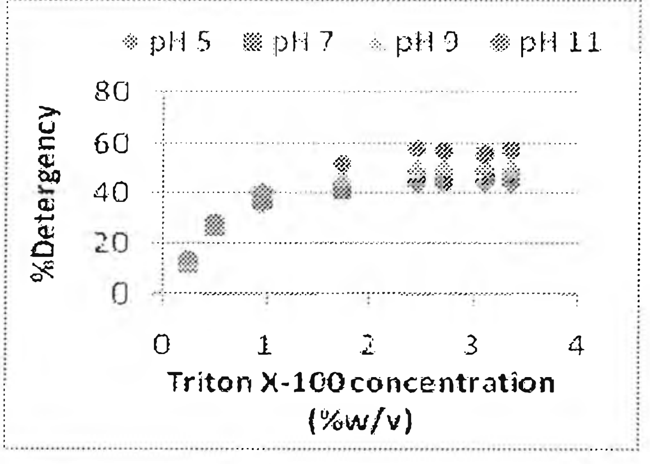

Figure 4.17 %Detergency on cotton/polyester blend fabric at different Triton X-100 concentrations and solution pH values

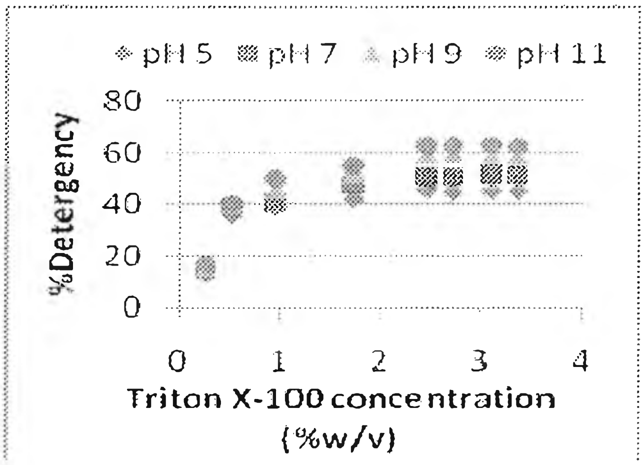

Figure 4.18 %Detergency on polyester fabric at different Triton X-100 concentrations and solution pH values

4.4 Contact Angle Results

4.4.1 Contact Angle Results of Anionic Surfactant

From Figures 19, 20 and 21, for any given solution pH and fabric type the contact angle of SDS solution decreased with increasing SDS concentration and leveled off when the SDS solution reached the CMC. For any given type of fabric and SDS concentration an increase in solution pH decreased slightly the contact angle of SDS solution. Figures 19, 20 and 21 show the contact angle of SDS solution on the carbon black, polyester/cotton blend and the polyester surfaces, respectively.

In comparisons among the three fabrics, the degree of contact angle of SDS solution was found to be in the following order: polyester > carbon black > polyester/cotton blend corresponding to the degree of hydrophobicity of the studies surfaces: polyester > carbon black > polyester/cotton blend. It should be noted that the contact angle on the cotton fabric would not measured because the high water adsorotion.

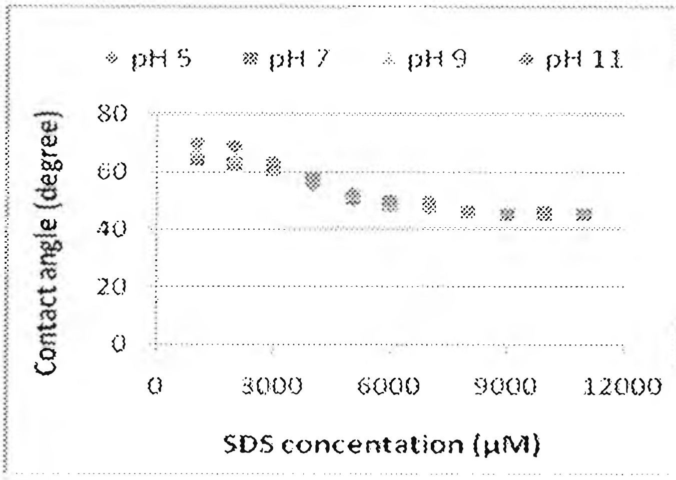

Figure 4.19 Contact angle of SDS solution on carbon black at different SDS concentrations and solution pHs.

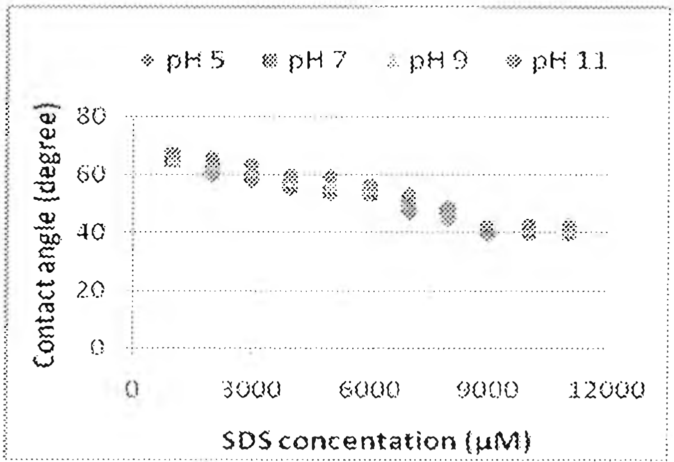

Figure 4.20 Contact angle of SDS solution on polyester fabric at different SDS concentrations and solution pHs.

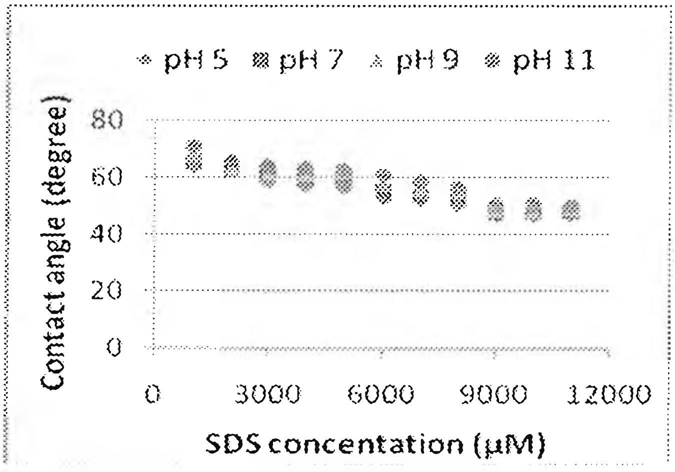

Figure 4.21 Contact angle of SDS solution on polyester/blend fabric at different SDS concentrations and solution pHs

4.2 Contact Angle Results of Nonionic Surfactant

From Figures 21, 22 and 23, the contact angle of Triton X-100 solution on these three surfaces showed the similar trends as compared to the case of SDS. Interestingly, the effect of solution pH on the contact angle of SDS solution on any surfaces was found to be higher than Triton X-100. In addition for any given type surfaces the contact angle of Triton X-100 solution is significantly lower than the contact angle of SDS solution. It is related to their chemical structure, where the branch hydrophobic group of Triton X-100 causes much stronger adsorption on surface in comparison with SDS, which contains shorter hydrophobic akyl chain.

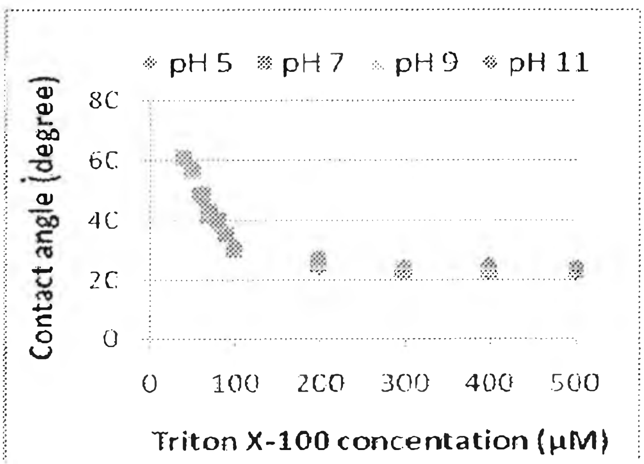

Figure 4.22 Contact angle of Triton X-100 solution on carbon black at different Triton X-100 concentration and solution pHs.

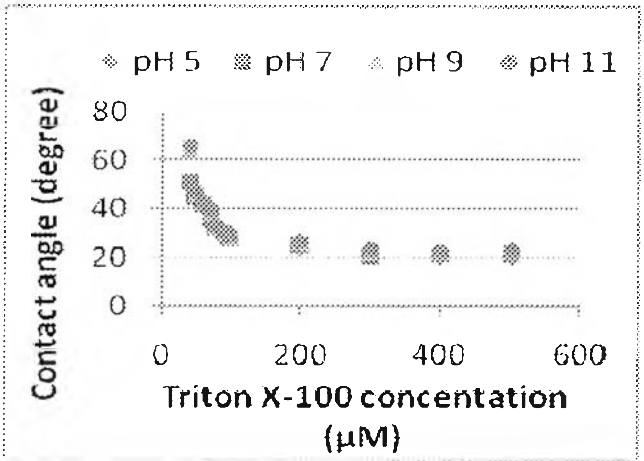

Figure 4.23 Contact angle of Triton X-100 solution on polyester/blend fabric at different Triton X-100 concentration and solution pHs.

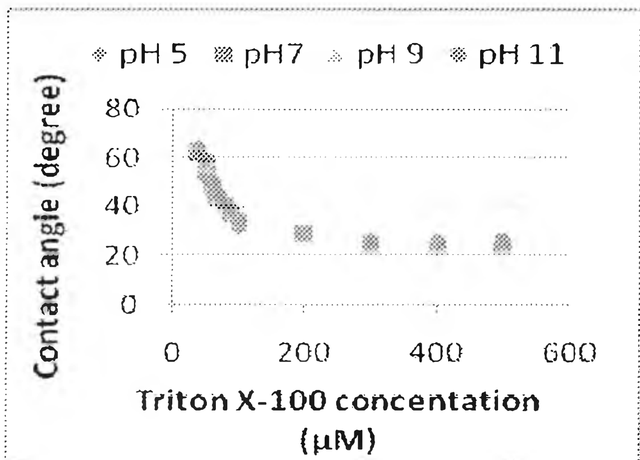

Figure 4.24 Contact angle of Triton X-100 solution on polyester fabric at different Triton X-100 concentration and solution pHs.