



CHAPTER IV

APPLICATION OF ADMICELLAR POLYMERIZATION IN FIBER REINFORCED CONCRETE

4.1 Abstract

Admicellar polymerization is the polymerization process of monomers solubilized in adsorbed surfactant bilayer which is one of methods used for surface modification of a substrate. In this research, polyester fabric surface was modified via admicellar polymerization technique using poly(methyl acrylate) as monomers to improve the hydrophilicity of polyester surface for using as reinforcement in concrete. The increase in the hydrophilicity of the treated fabric surface was determined by the drop testing. From the results, it was found that the optimum condition for admicellar polymerization is 1.5 mM DBSA with 0.05 M NaCl at pH 4. Characterizations of modified fabric were carried out using FTIR and SEM techniques. From FTIR spectra and SEM micrographs, it was confirmed that an ultrathin film of poly(methyl acrylate) was successfully coated on polyester fabric. The condition for admicellar polymerization which gave polyester surface with highest hydrophilicity is 1.5 mM DBSA, 0.05 M NaCl, 1:2 DBSA:MA molar ratio, and 1:5 AIBN:MA molar ratio. Flexural test showed that elastic load and flexural deformation of reinforced concrete with treated fabric was improved by 270% and 180%, respectively, when compared to reinforced concrete with untreated fabric.

Keywords: Admicellar polymerization; Surface modification; Polyester fabric; Poly(acrylic acid); Poly(methyl acrylate); Fiber-reinforced concrete

4.2 Introduction

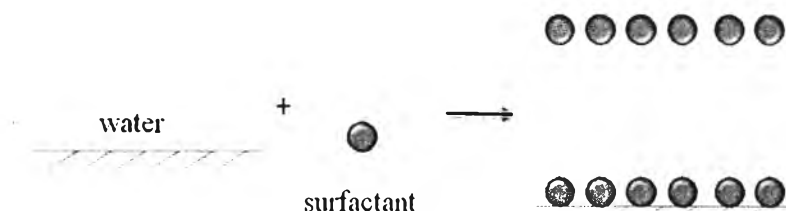
Reinforced concrete is widely used for structural applications such as flooring, housing, precast and pavement. Normally, steel is used as reinforcing material due to its superior qualities, in terms of strength and compatibility with concrete. However, durability of reinforced concrete as a result of corrosion of steel is a serious problem. The introduction of innovation non-metallic materials is developed to overcome this problem. Fiber reinforcement polymer materials have evolved as a result of new developments in the fields of plastics and fiber composites.

Polyester, Poly(ethylene terephthalate), is a linear, hydrophobic polymer commonly used for geotextile application as a reinforcing material. It has excellent toughness and dimensional stability. However, Its hydrophobic nature can be disadvantage for adhesion between the fiber and matrix. The adhesion can be enhanced by surface modification of fiber surface. There are several surface modification techniques to increase the fiber/matrix bonds such as chemical modification [1,2] corona treatment [3], surface grafting polymerization [4-6] and plasma treatment [7-11]. All of these techniques will improve interfacial strength directly because the processes generate polar or functional chemical groups on the fiber surface. The presences of polar groups enhance the surface reactivity with the matrix in order to promote excellent adhesion. However, these techniques have the drawbacks of high cost, high energy consumption, special equipment requirement and working with a gas phase, which is difficult to control. Therefore, admicellar polymerization is one of the surface modification methods which requires simple instruments and can be carried out easier.

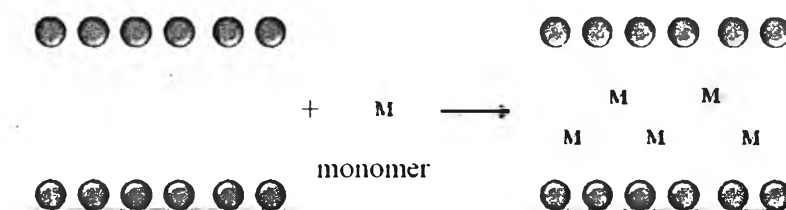
Admicellar polymerization is a technique to create thin film of polymer on a substrate by polymerization of monomer solubilized in absorbed surfactant bilayer at a surfactant concentration below the critical micelle concentration (CMC). The thin-film polymerization process consists of 4 steps (as illustrated in Fig. 4.1): 1) admicellar formation, which is the adsorption of surfactant at the solid/liquid interface to form bilayer (admicelle); 2) monomer adsobulization, which organic monomers preferentially partition into the core of the admicelle; 3) polymer

formation, which initiator is added to start the polymerization in the admicelle; and, 4) surfactant removal, which the outer surfactant layer is washed out in order to expose the polymer thin film on the substrate surface.

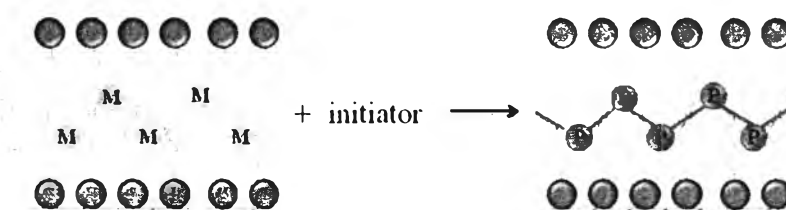
Step 1: Admicellar Formation



Step 2: Monomer Adsolubilization



Step 3: Polymer Formation



Step 4: Surfactant Removal

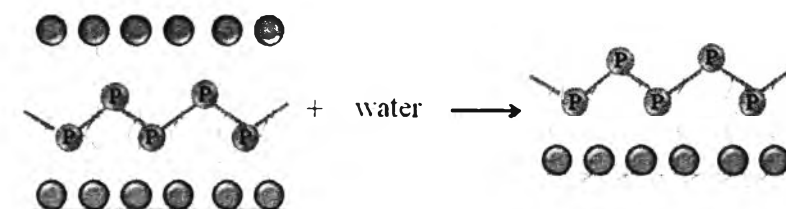


Figure 4.1 Schematic of the four steps of admicellar polymerization.

In this work, admicellar polymerization of poly(methyl acrylate) on the hydrophobic polyester fabric surface was studied. After the polymerization reaction, the PMA-coated polyester fabric introduces carboxylic groups to the surface of the fabric to improve the hydrophilicity of the polyester fabric. The study was focused

on the optimum conditions; e.g. adsorption time, surfactant concentration, surfactant adsorption isotherm. Also, morphology of polymer-modified surface and interaction between polymer-modified surface of polyester fabric and concrete were studied.

4.3 Experimental

4.3.1 Materials

Methyl acrylate monomer (99% purity, MA, $C_4H_6O_2$) was purchased from Fluka. 2,2'-Azobisisobutyronitrile (98% purity, AIBN, $C_8H_{12}N_4$), a water insoluble initiator, and Dodecylbenzenesulfonic acid, sodium salt (DBSA, $C_{18}H_{29}SO_3Na$), an anionic surfactant, were purchased from Aldrich. Sodium chloride (NaCl) was obtained from Carlo Erba. Absolute ethyl alcohol and toluene (A.R. grade) were purchased from Lab Scan. Concentrated hydrochloric acid and sodium hydroxide (37%, J.T. Baker Inc., USA and Carlo Erba, Italy, respectively) were used for the adjustment of pH.

Polyester fabric was washed several times in a washing machine using hot water until it was free from any remaining lubricants and finishes prior to use. Mixed cement was purchased from Siam Mortar Co., Ltd. Deionized water was used in all experimental work.

4.3.2 Measurements

4.3.2.1 UV-Spectrophotometer

The amounts of DBSA and methyl acrylate in the supernatant were measured using Shimadzu, model 2550 UV-spectrophotometer at wavelength 224 and 238 nm, respectively.

4.3.2.2 Fourier Transform Infrared Spectroscopy (FT-IR)

The FT-IR spectra of poly(methyl acrylate) which extracted from treated polyester fabric was obtained using a Nicolet Nexus 670 FT-IR spectrometer in the frequency range of $4000-400\text{ cm}^{-1}$ at a resolution of 4 cm^{-1} to confirm the

formation of a polymeric thin film on the fabric surface. The thin film of poly(methyl acrylate) on polyester fabric was extracted by using boiled toluene. After the solvent was evaporated off, the remaining polymer was analyzed and KBr pellet technique was applied in the preparation of powder samples.

4.3.2.3 Scanning Electron Microscope (SEM)

Surface morphology of treated polyester fabric was studied by JOEL 5200-2AE scanning electron microscope to observe the uniformity and coverage of the film. The samples were obtained randomly from the modified fabric and sputter coated with gold under vacuum prior to observation to make them electrically conductive.

4.3.2.4 Contact Angle Measurement

Static contact angles with water were measured for both sides of the fabric surface using sessile drop method on a DSA10-Mk2 contact angle measuring instrument. Measurements were carried out at 30°C. For each sample, five drops of liquid are placed in different parts of the sample on both sides. A drop of test liquid was introduced by injecting exactly 10- μ L of test liquid with a 10- μ L syringe. The average value of all measurements was then calculated.

4.3.2.5 Flexural Sample Preparation and Experiment Procedure

A measured amount of wet cement mortar was poured into a mold just enough to fill half of the mold and then the untreated or treated polyester fabric was introduced onto the wet cement. After that, another measured amount of wet cement was poured into the mold to cover another side of the polyester fabric. The samples were allowed to harden in air for 4-5 day, after which, the flexural tests were carried out using Instron Universal Testing Machine model 5567.

4.3.3 *Methodology*

4.3.3.1 Determination of Equilibrium Adsorption Time

The solution of DBSA of a required concentration and pH was first prepared ([DBSA] = 5mM, pH = 4). A 25 ml aliquot of the solution was pipetted into a 32 ml vial containing 0.5 g of polyester fabric. The sealed vial was placed in a shaker bath at 30°C for a required time. Small amount of supernatant was sampled at different interval to determine the equilibrium adsorption time of DBSA on polyester fabric. The concentration of DBSA in solution was determined by Shimadzu UV-spectrophotometer model 2550. The adsorbed DBSA on polyester fabric was calculated by taking the difference between the initial and final concentrations of DBSA. A plot of time versus adsorbed surfactant was carried out to determine the equilibrium adsorption time when there was no longer change in adsorbed surfactant. The wavelength of maximum adsorption for aqueous solution of DBSA was investigated from the calibration curve.

4.3.3.2 Determination of Surfactant Adsorption Isotherm

The adsorption isotherm of DBSA on polyester fabric was obtained by exposing 0.4g of polyester fabric to 25 ml of DBSA solution of known initial concentration. The mixture was equilibrated at 30°C for 15 h, which is equilibrium adsorption time, in a sealed vial. The amount of DBSA in supernatant was measured by a UV spectrometer. The initial DBSA concentration in this experiment was varied from 10 to 6,000 μM , which covered the region below and above the CMC of DBSA. A plot of equilibrium supernatant concentration versus the amount of adsorbed surfactant yielded, which is known as the surfactant adsorption isotherm was conducted.

4.3.3.3 Determination of Monomer Adsolubilization Isotherm

Stock methyl acrylate-in-surfactant and surfactant solution were used to prepare samples containing constant DBSA concentration with different methyl acrylate concentration. The methyl acrylate/DBSA solution of various ratios was added to 0.4g of polyester fabric in 32 ml vials and sealed with paraffin film.

The mixture was allowed to equilibrate at 30°C for 15 h in a shaker bath. The methyl acrylate concentrations before, and after equilibrium were measured by Shimadzu UV-spectrophotometer model 2550. Adsolubilization of methyl acrylate was calculated by simple mass balance. The adsolubilization isotherm was plot between adsolubilization of methyl acrylate on polyester fabric ($\mu\text{mol/g}$) and equilibrium concentration of methyl acrylate solution (M).

4.3.3.4 Admicellar Polymerization

Polymerization of methyl acrylate on polyester fabric was carried out using optimum DBSA concentration and pH with the desired amount of NaCl, DBSA : monomer molar ratio, initiator : monomer molar ratio. A $5 \times 5 \text{ cm}^2$ polyester fabric was placed in a 32 vial containing 30 ml of the DBSA solution. The sealed vial was placed in a shaker bath at 30°C for 15 h to reach equilibrium. Then the temperature was raised to 75°C to initiate the polymerization reaction. After the polymerization, the reaction were quenched by immersion the vials in an ice water bath. The treated fabrics were removed from the vials and washed 3 times in distilled water at 80°C for 30 min to remove the upper layer of DBSA and expose the polymer film. Finally, the fabrics were placed in an oven overnight at 65°C to remove any remaining water.

4.3.3.5 Characterization of The Treated Fabric

4.3.3.5.1 *Identification of The Coated Film*

The presence of poly(methyl acrylate) films was confirmed by using a Nicolet Nexus 670 FT-IR spectrometer in the frequency range of 4000-400 cm^{-1} at a resolution of 4 cm^{-1} . The poly(methyl acrylate) thin films on polyester fabrics were extracted by using boiled toluene. After the solvent was evaporated off, the remaining polymer was analyzed and KBr pellet technique was applied in the preparation of the samples.

4.3.3.5.2 *Surface Morphology of The Treated Fabric*

The morphology of the treated fabric surface was studied by Scanning Electron Microscope JOEL, Model JSM 5200 to observe the uniformity

and coverage of the polymeric film. The samples were obtained randomly from different positions of the fabric and sputter coated with gold under vacuum prior to observation to make them electrically conductive. Magnification used in the study was x3500.

4.3.3.6 Testing

4.3.3.6.1 *Contact Angle Measurement*

Static contact angles with water were measured for both sides of the fabric surface using sessile drop method on a DSA10-Mk2 contact angle measuring instrument. Measurement was carried out at 30°C. For each sample, five drops of liquid are placed in different parts of the sample on both sides of the samples. A drop of test liquid was introduced by injecting exactly 10- μ L of test liquid with a 10- μ L syringe. Contact angle was measured after the drop is put down from the syringe every second for 30 second using Tacker man function. The average value of all measurements was then calculated.

4.3.3.6.2 *Flexural Test (Sample Preparation and Experiment Procedure)*

Wet cement mortar was poured into a mold to fill half the mold and then the untreated or treated polyester fabric was introduced onto the wet cement. After that, another portion of wet cement was poured into the mold to cover another side of the polyester fabric (see Figure 4.2). The samples were allowed to harden in air for a week, after which, the flexural tests were carried out using Instron Universal Testing Machine model 5567. The specimen dimension is 100 mm in width, 100 mm in length, and 5 mm in depth. The test conditions are 1 KN Load cell, 80 mm support span, and at rate of crosshead motion 0.5 mm/min. Figure 4.2 shows the flexural test configuration.

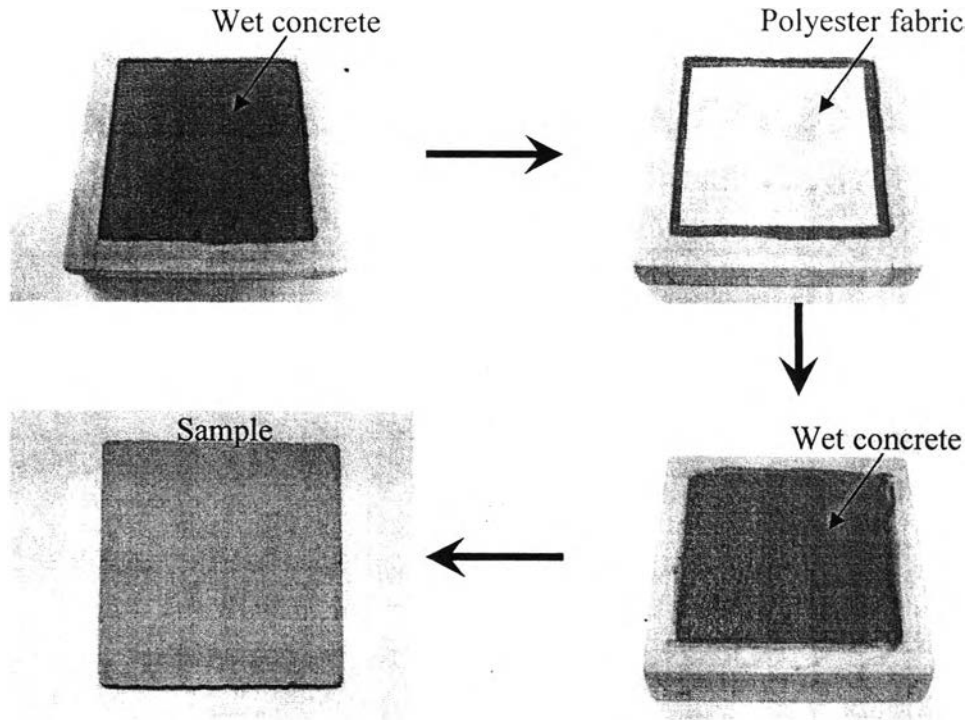


Figure 4.2 Flexural sample preparation.

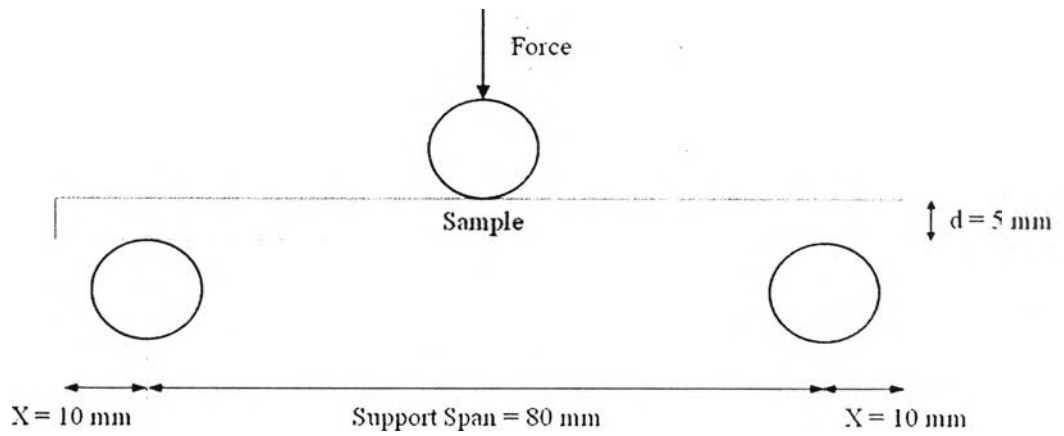


Figure 4.3 The flexural test configuration.

4.4 Results and Discussion

4.4.1 Determination of Equilibrium Adsorption Time

Equilibrium adsorption time of DBSA on polyester fabric was carried out to establish (see Figure 4.4) the required time for DBSA to adsorb on the fabric. The plot of adsorption against time show that DBSA adsorbs immediately on to polyester fabric at 30°C and pH 4. The initial DBSA concentration used was 5 mM, which was well above CMC of DBSA which is around 1.2 mM. The adsorption of the surfactant was found to increase rapidly until about 13 h after which it started to slow down and became constant at 16 $\mu\text{mol/g}$ of polyester after 15 h. Therefore, in subsequent experiments, the adsorption step was carried out for 15 h to ensure that the surfactant adsorbed on the fabric surface and reached the equilibrium adsorption.

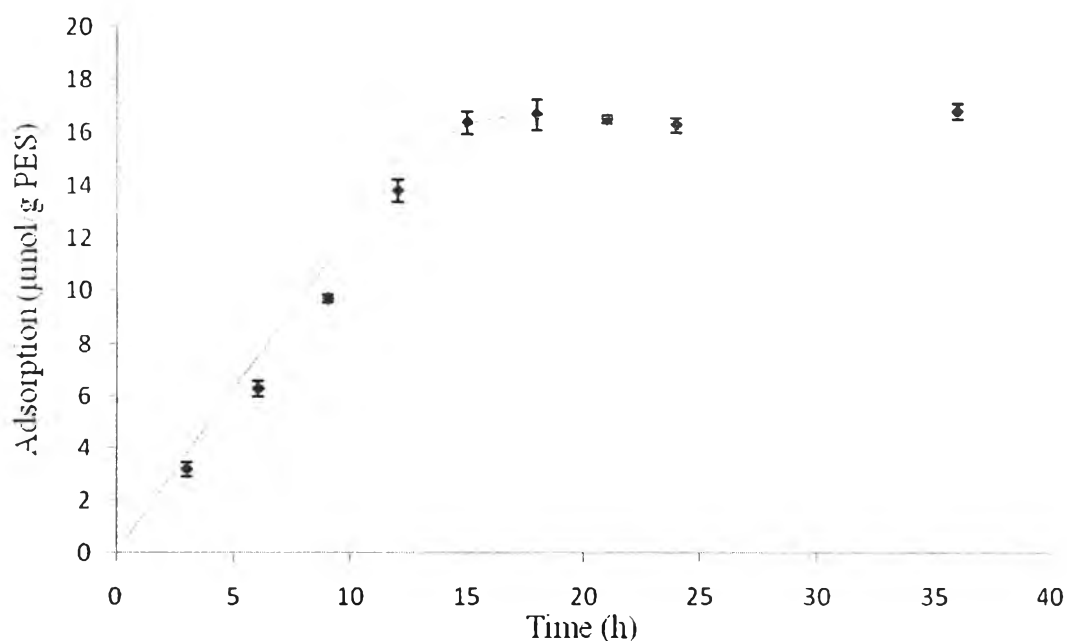


Figure 4.4 Rate of adsorption of DBSA on polyester fabric (Temp = 30°C, [DBSA] = 5 mM, pH = 4).

4.4.2 Determination of Surfactant Adsorption Isotherm

The adsorption isotherm of DBSA on polyester fabric at pH 4 is presented in Figure 4.5. It can be seen that the adsorption of DBSA on polyester fabric

conforms to S-shaped adsorption isotherm for an ionic surfactant on neutral substrate. Initially, the amount of DBSA adsorbed on polyester fabric sharply increase with an increase in DBSA concentration. As the DBSA concentration increased further, the slope started to decline, leading eventually to a constant value. In admicellar polymerization process, the concentration of surfactant in the system should be just below or near its CMC to ensure significant coverage while avoiding the emulsion polymerization. From the adsorption isotherm, the concentration of 1.5 mM DBSA, which is near the CMC of DBSA, was chosen for subsequent polymerization reactions.

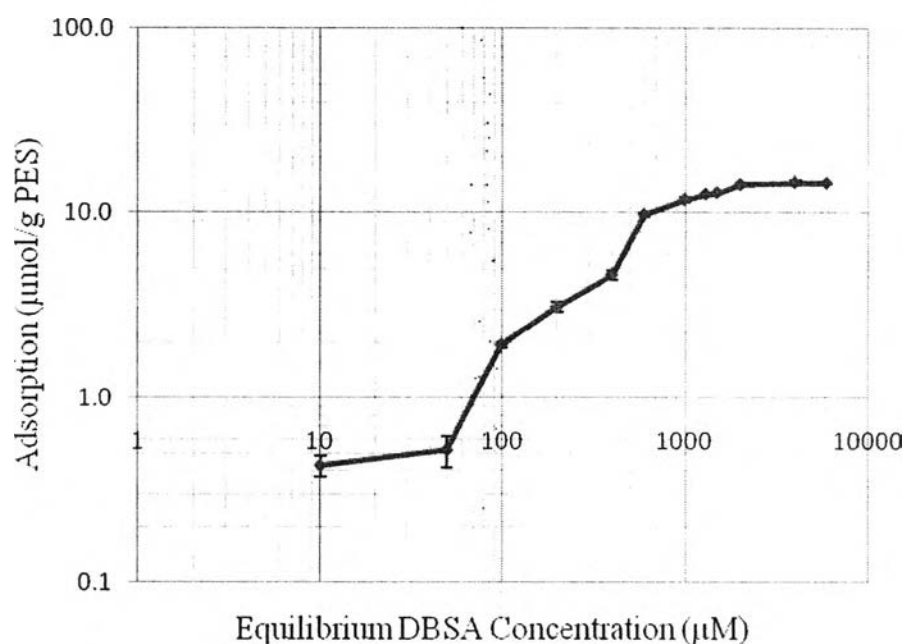


Figure 4.5 Adsorption isotherm of DBSA on polyester fabric (Temp. = 30°C, time = 15 h, pH = 4).

4.4.3 Determination of Monomer Adsolubilization Isotherm

Adsolubilizations of methyl acrylate in the admicellar at various amounts of added salt, were studied. As shown in Figure 4.6, the amount of adsolubilized monomers increases when the equilibrium concentration of monomers increases. When adding 0.05 M NaCl, methyl acrylate were adsolubilized into a bilayer of surfactant higher than without salt. Due to the addition of neutral electrolyte such as salt enhances counterion binding, which reduces the electrostatic repulsion between

the surfactant head group ions. The decrease in the electrostatic repulsion between the surfactant head group ions, allows surfactants to pack more closely on the surface of polyester fabric, decreasing the effective head group area to permit more DBSA adsorption and in turn more methyl acrylate adsolubilization. Surprisingly, when adding 0.15 and 0.25 M of NaCl, methyl acrylate could be adsolubilized into a bilayer of surfactant was lower than when no salt added to the system. This could be due to the fact that when salt is introduced too much to the system, counterion binding was increases, the polarity of the head groups decreases seriously, this cuts down on interactions between the head groups and monomers.

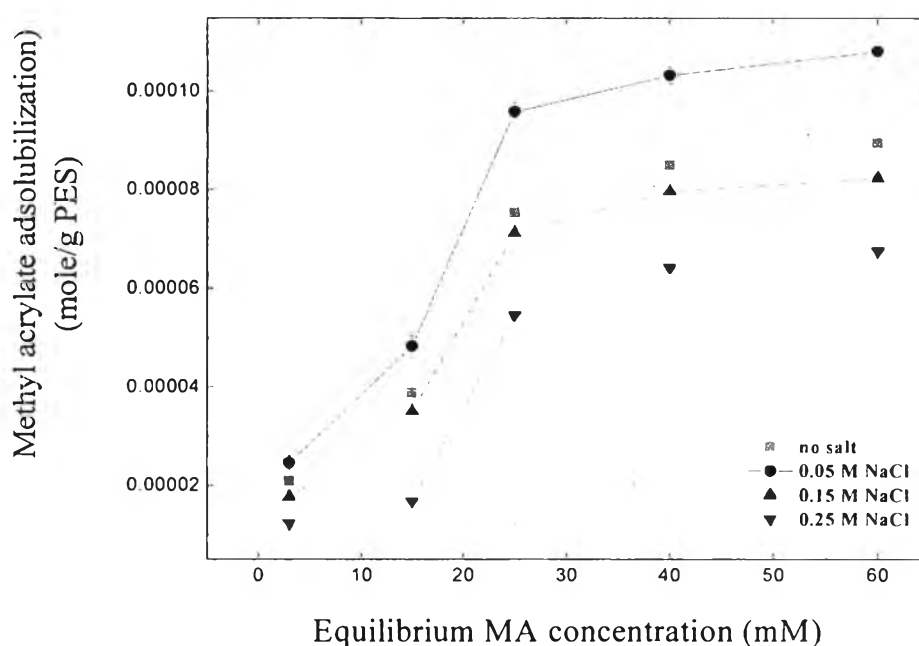


Figure 4.6 The adsolubilization isotherm of methyl acrylate with different amounts of salt.

4.4.4 Study of Admicellar Polymerization

Results from the earlier experiments were used in establishing the condition for conducting the admicellar polymerization of methyl acrylate (MA) on the polyester fabric substrate. For admicellar polymerization of MA on the polyester fabric, the initial concentration of DBSA was fixed at 1.5 mM DBSA with 0.05 M NaCl. Moreover, the polymerization process was carried out at pH 4 and the

DBSA:Monomer molar ratios and AIBN:Monomers molar ratios were varied as shown in the Table 4.1.

Table 4.1 The molar ratios of DBSA:Monomer and AIBN:Monomer at 1.5 mM DBSA, Temp. = 30°C, pH = 4

DBSA:Monomer	AIBN:Monomer
1:2	1:5, 1:10, 1:15, 1:20
1:5	1:5, 1:10, 1:15, 1:20
1:10	1:5, 1:10, 1:15, 1:20
1:15	1:5, 1:10, 1:15, 1:20

4.4.5 Characterization of The Treated Fabric

4.4.5.1 Identification of The Coated Film

Ultrathin films of poly(methyl acrylate) was coated on polyester fabric using the admicellar polymerization process. This was confirmed by FTIR. IR spectrum of the extracted PMA film on polyester fabric is presented in Figure 4.7. The results are presented in absorbance arbitrary units. It can be observed that the extracted PMA from the admicellar-treated sample showed many characteristic peaks of PMA which reported in Table 4.2.

Table 4.2 Main FT-IR absorption bands of PMA

Wavelength (cm ⁻¹)	Corresponding to
2980-2850	Aliphatic C-H stretching
1730-1720	C=O stretching due to carbonyl groups
1450-1350	C-H bending vibration
1270-990	C-O-C stretching vibration
850-700	CH ₂ rocking vibration

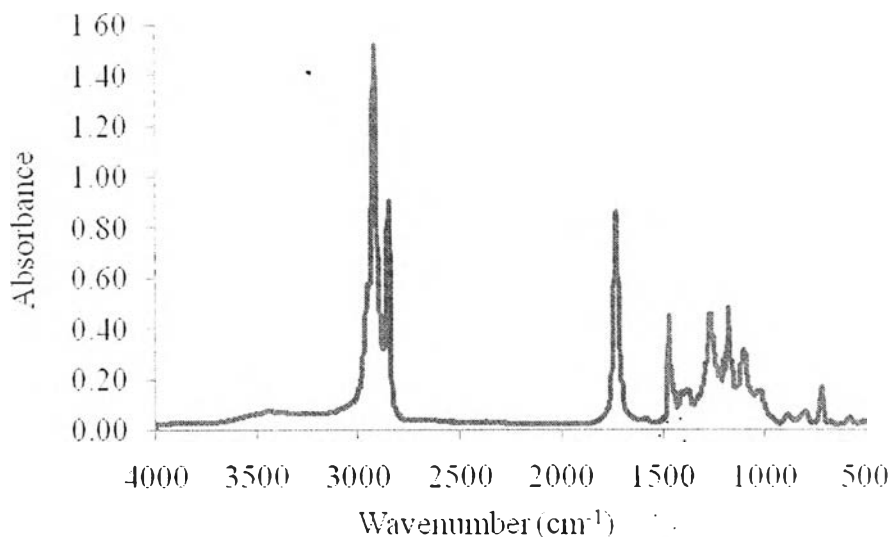


Figure 4.7 FTIR spectrum of extracted PMA.

4.4.5.2 SEM Micrographs of The Treated Fiber Surface

SEM images of untreated and treated polyester fabrics with PMA are presented in Figure 4.8 (a), and (b) respectively. SEM micrographs of the untreated polyester fabrics show clear and relatively smooth fiber surfaces. Figure 4.7 (b) shows the present of PMA on the treated polyester fabric surfaces. These observations were in agreement with the FTIR results and confirm that the PMA film had been coated on the treated polyester fabrics by admicellar polymerization. However, it can be observed that the polymers were not uniform and did not cover the entire fiber surface.

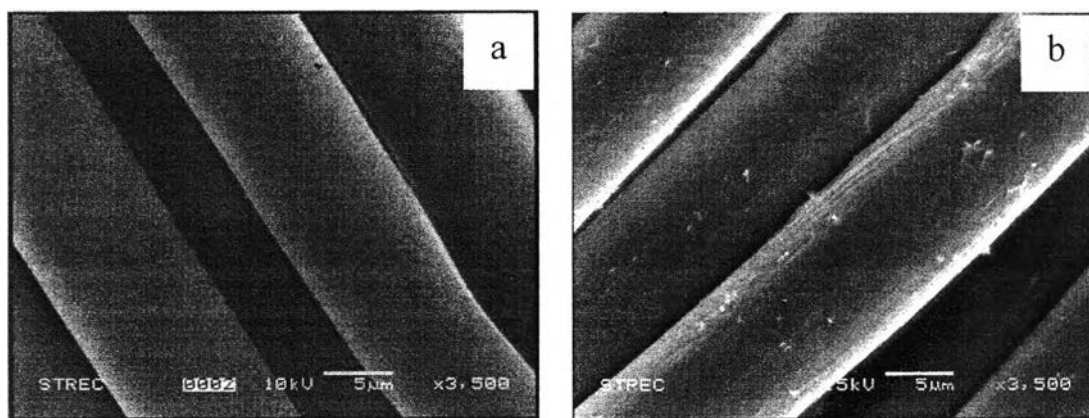


Figure 4.8 SEM micrographs of (a) untreated polyester fabric and (b) PMA coated polyester fabric ($\times 3,500$).

4.4.6 Effects of The Amount of Monomer and Initiator

Monomer concentration and initiator concentration were important factors affecting the characteristics of polymer film formed on the substrate. Therefore the monomer concentration and initiator concentration were studied to determine the optimum monomer concentration and initiator concentration used for subsequent studies.

4.4.6.1 Effect of Monomer Concentration

The effect of varying the amount of monomers is shown in Figures 4.9-4.12. The DBSA concentration was fixed at 1.5 mM while the DBSA:monomer molar ratio was varied at 1:2, 1:5, 1:10, and 1:15. For DBSA: monomer ratio at 1:2, the polymer thin film on fiber surface is thin and smooth, when compared to the other ratios of 1:5, 1:10, and 1:15. When the amount of monomer increased, the coated films thickness is also increased and the surface of the film becomes rougher. Matarredona *et al.* (2003) [13] showed that the thickness of the polymer film increased at high concentration of monomer in the admicelle during the polymerization reaction increased. This resulted from as the polymerization reaction progressed, more monomer could have partition into the admicelle and reacted to form additional polymer leading to the increase of the film thickness. Moreover, at high amount of monomers, adsolubilized monomers were aggregated as a droplet on the substrate surface and could be polymerized to give a thick and rough surface of polymer film. From the SEM observations, DBSA:MA ratio that will impart better adhesion between fabric and concrete is 1:2. This is due to the smoother surface of the modified fabric.

4.4.6.2 Effect of Initiator Concentration

The effect of initiator and monomer ratio on the treated polyester fabric was also studied (see Figures 4.13). The initiator: monomer ratio seemed to play an important role on the morphology of the film formed on the fabric. The initiator: monomer ratio was varied from 1:5, 1:10, 1:15 to 1:20. As observed in Figures 4.13, the highest initiator: monomer ratio resulted in the roughest films on

the treated polyester fabric sample. However, when initiator: monomer ratio was reduced, the roughness of the polyester fabric was also reduced. Pongprayoon *et al.* (2002) [12] reported that higher concentration of initiator in the admicellar polymerization led to lower molecular weights of polymer with shorter chains forming a patchwise morphology on the fabric surface. On the other hand, the lowest initiator: monomer ratio led to higher molecular weights of polymer with longer and more entangled chains, resulting in polymer almost coated the entire surface with less roughness.

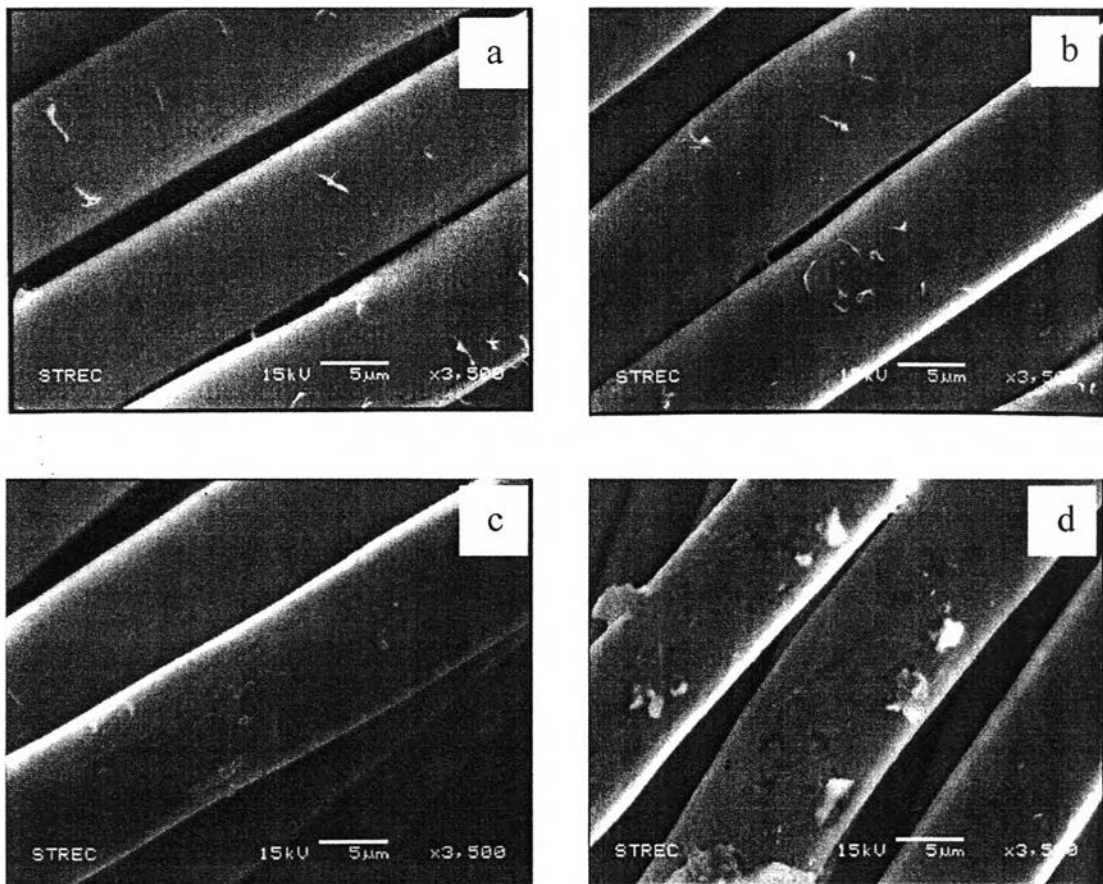


Figure 4.9 SEM micrographs of treated polyester fabric using different monomer concentration with 1.5 mM DBSA, 0.15 M NaCl, and AIBN:MA ratio 1:20 at various DBSA:MA molar ratios; (a) 1:2; (b) 1:5; (c) 1:10; (d) 1:15.

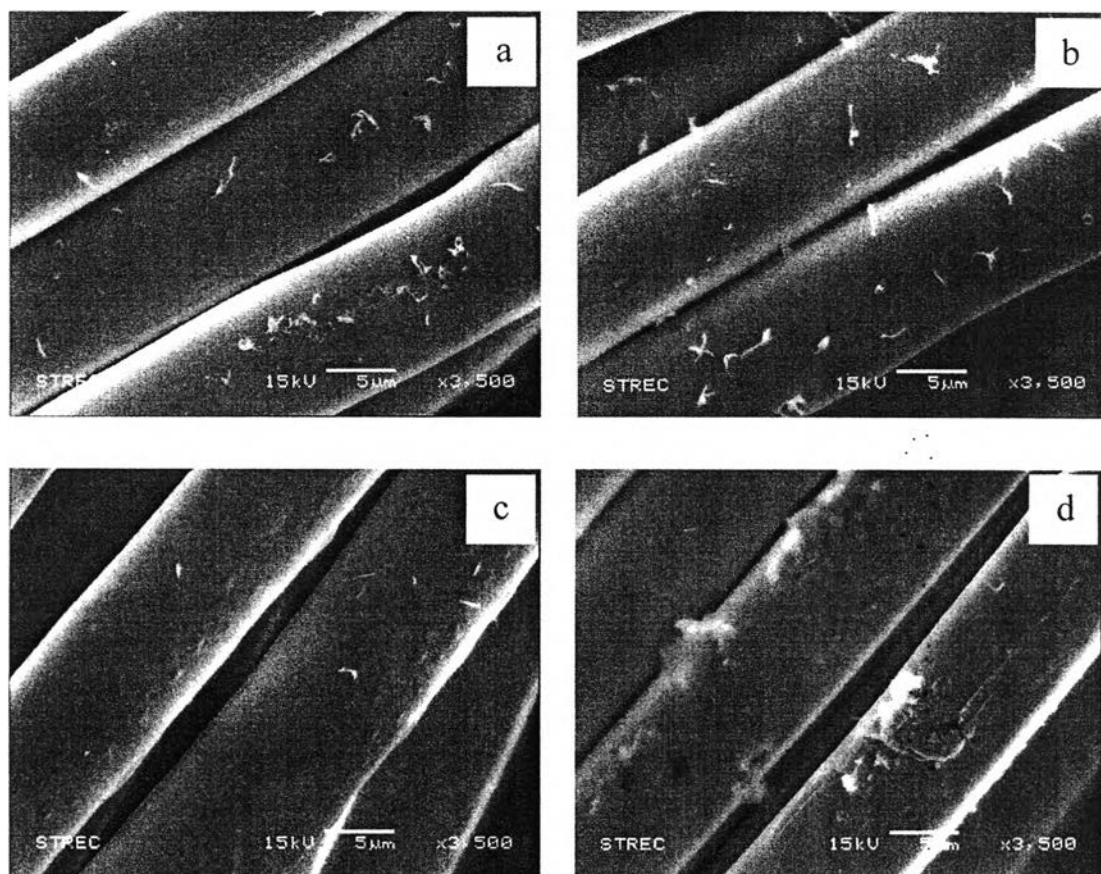


Figure 4.10 SEM micrographs of treated polyester fabric using different monomer concentration with 1.5 mM DBSA, 0.15 M NaCl, and AIBN:MA ratio 1:15 at various DBSA:MA molar ratios; (a) 1:2; (b) 1:5; (c) 1:10; (d) 1:15.

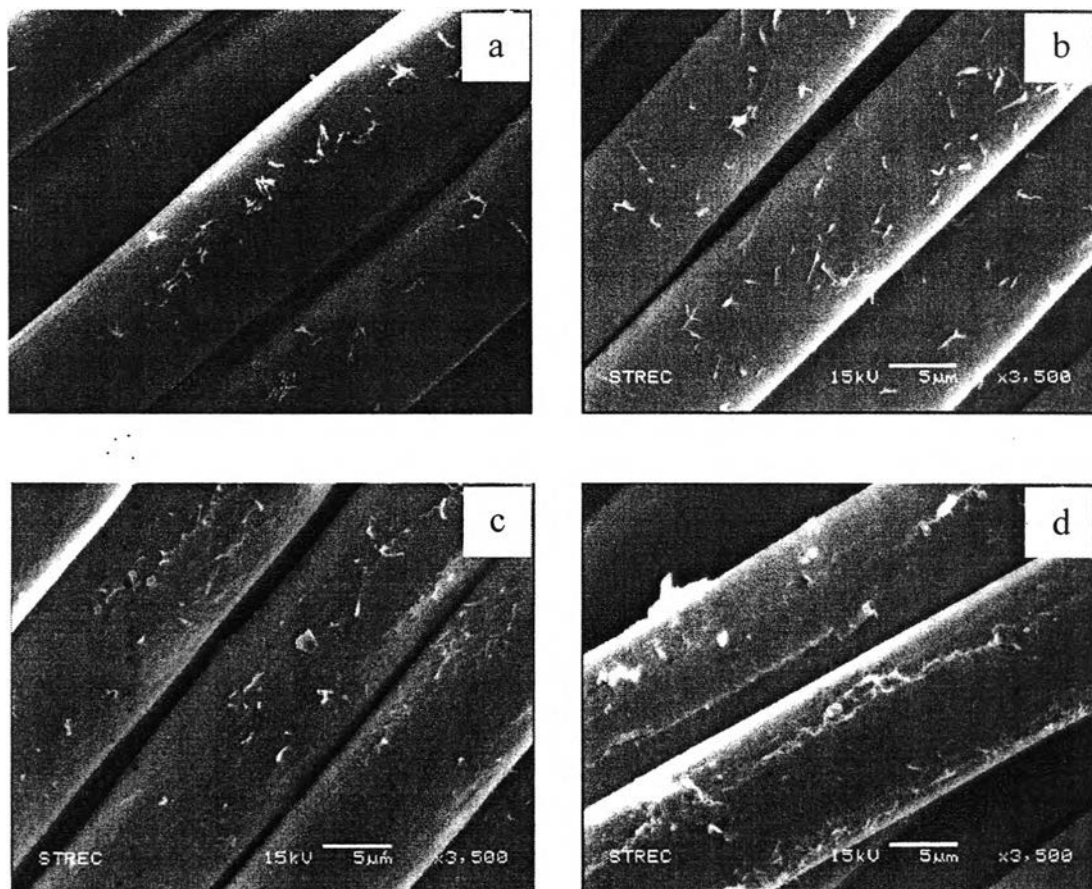


Figure 4.11 SEM micrographs of treated polyester fabric using different monomer concentration with 1.5 mM DBSA, 0.15 M NaCl, and AIBN:MA ratio 1:10 at various DBSA:MA molar ratios; (a) 1:2; (b) 1:5; (c) 1:10; (d) 1:15.

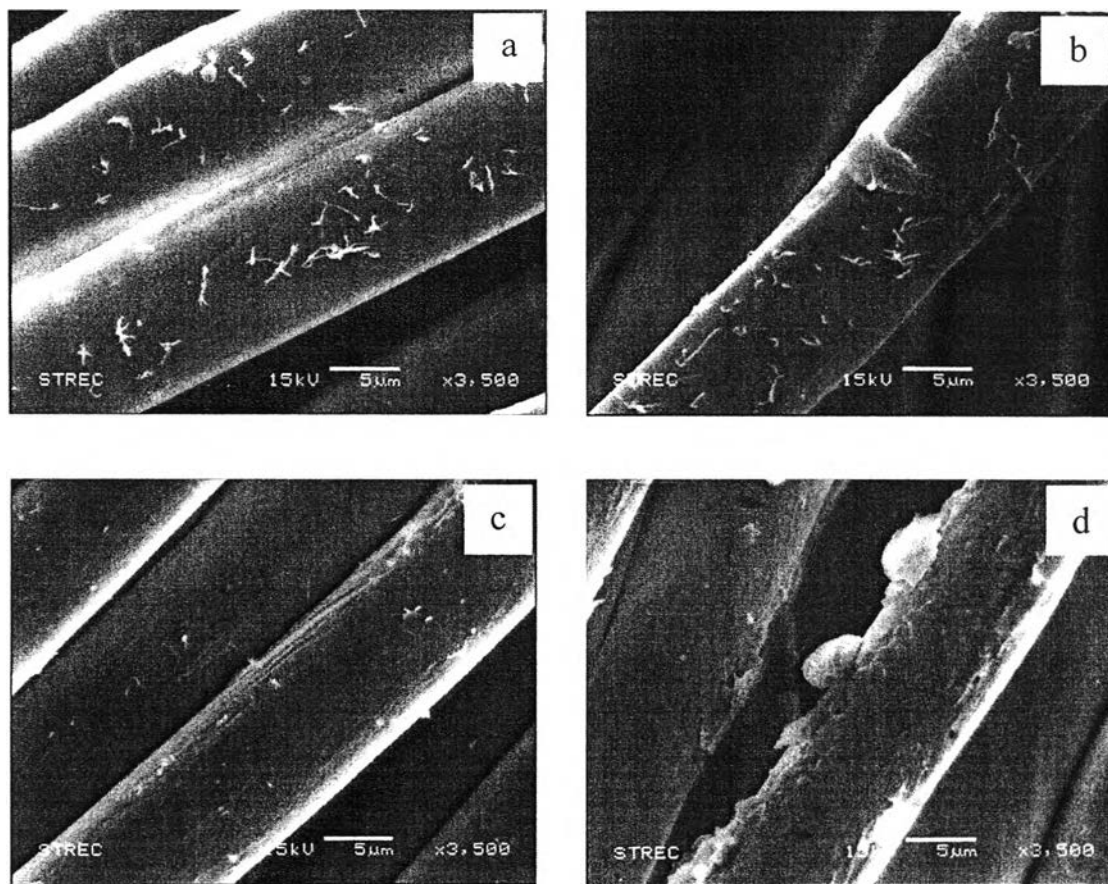


Figure 4.12 SEM micrographs of treated polyester fabric using different monomer concentration with 1.5 mM DBSA, 0.15 M NaCl, and AIBN:MA ratio 1:5 at various DBSA:MA molar ratios; (a) 1:2; (b) 1:5; (c) 1:10; (d) 1:15.

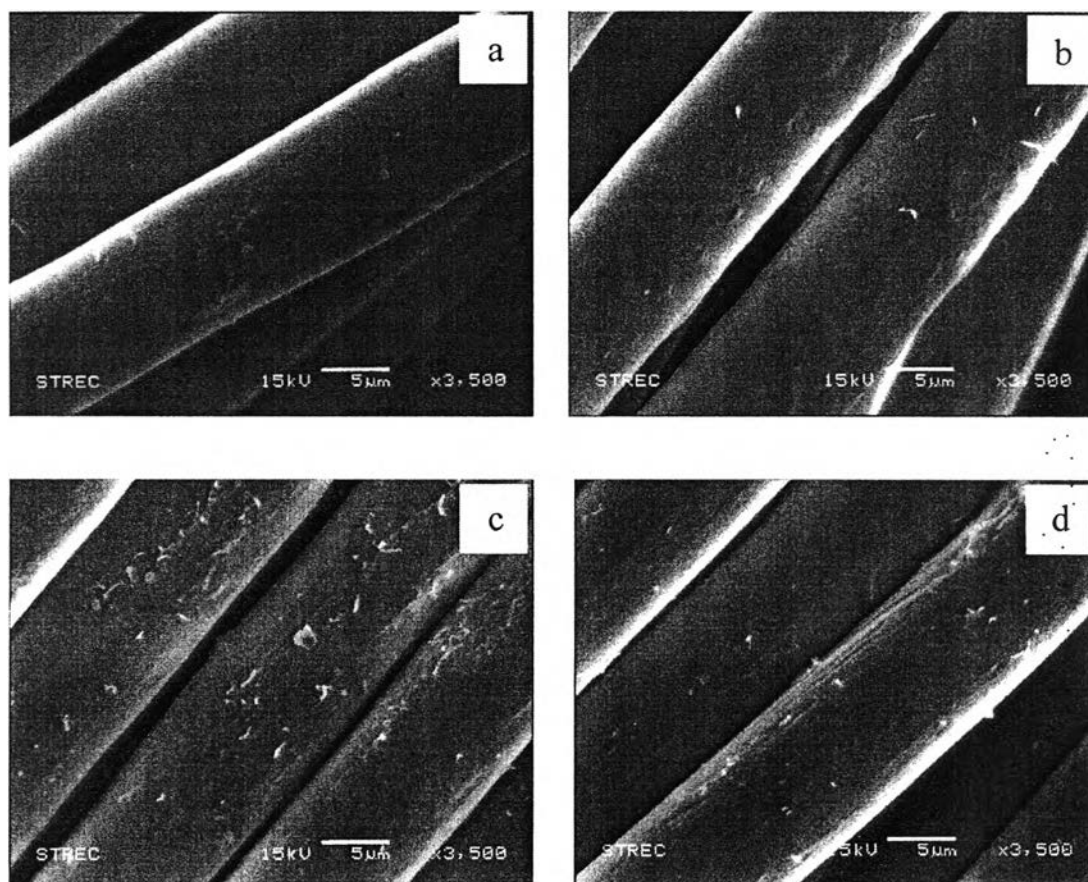


Figure 4.13 SEM micrographs of treated polyester fabric using different initiator concentration with 1.5 mM DBSA, 0.15 M NaCl, and DBSA:MA ratio 1:10 at various AIBN:MA molar ratios; (a) 1:20; (b) 1:15; (c) 1:10; (d) 1:5.

4.4.7 Contact Angle Measurement

Contact angle measurement was used to study the hydrophilic characteristic of the obtained treated polyester fabric. Contact angle measurements were carried out on the sample subjected to different polymerization conditions. Table 4.3 presents average contact angles obtained from PMA coated samples. As the amounts of monomer increased, the contact angles of the treated fabrics increased corresponding to the roughness of the treated fabric surface. The higher monomer concentration created the rougher surface which has the higher contact angle than the smooth surface, lower monomer concentration. In addition, as the amounts of initiator increased, the contact angles of the treated fabrics decreased. Although higher

concentration of initiator in the admicellar polymerization led to lower molecular weights of polymer with shorter chains, the molecular weight of the polymer did not affect the hydrophilicity of the modified polyester surface. Pongprayoon *et al.* (2002) [12] reported that the hydrophilicity of the fabric does not depend on the molecular weight of the polymer coated but depends rather on its amount. In the system using more initiator, more polymer was formed, leading to higher hydrophilicity.

From the results, The treated polyester fabric sample that gave the lowest contact angle, highest hydrophilicity, is at 1:2 DBSA:AA molar ratio and 1:5 AIBN:AA molar ratio. When the polyester fabric surface was modified to increase the hydrophilicity, the adhesion between fabric and matrix (concrete) was also enhanced. For this reason, the treated polyester fabrics using the above condition in the subsequent studies.

Table 4.3 Average contact angles of treated polyester fabrics modified with methyl acrylate at different conditions

AIBN:MA molar ratio	Average contact angle (θ) deg			
	DBSA:MA molar ratio			
	1:2	1:5	1:10	1:15
1:20	130.4 \pm 4.1	132.6 \pm 3.7	131.7 \pm 3.0	134.5 \pm 4.4
1:15	129.5 \pm 4.2	131.2 \pm 4.2	132.0 \pm 4.3	133.4 \pm 3.4
1:10	127.5 \pm 3.8	131.1 \pm 4.6	134.7 \pm 5.5	133.8 \pm 3.1
1:5	123.0 \pm 4.4	127.4 \pm 3.4	132.9 \pm 3.7	129.2 \pm 3.7

4.4.8 Flexural Test

Flexural tests were also carried out to study the hydrophilicity of the treated fabric samples. Treated polyester fabric with the highest hydrophilicity characteristic would provide the highest adhesion between the fabric and the matrix concrete. Flexural test results of plain concrete and untreated polyester reinforced concrete are present in Figure 4.14-4.15. Figure 4.14 shows that the elastic load of the untreated polyester reinforced concrete was improved slightly when compared to the plain concrete. This could be due to poor adhesion between the hydrophilic surface of

concrete and hydrophobic surface of polyester fabric. Therefore, the fabric was less effective as reinforcement material for the concrete to give little improvement in the elastic load. However, the untreated polyester reinforced concrete was more flexible than the plain concrete. The untreated fabric reinforced concrete has higher displacement of 210% when compared to the plain concrete (see in Figure 4.14). The elastic load and the displacement of treated polyester reinforced concrete from 1:2 DBSA:MA ratio were higher than untreated polyester reinforced concrete about 270% and 180%, respectively. From these results, it indicated that the polyester fabric surface which is hydrophobic was modified via admicellar polymerization of methyl acrylate, a polar polymer, to improve the hydrophilicity of the surface so that the adhesion between these modified polyester fabric and the concrete is higher than the unmodified polyester fabric and the concrete. This resulted in the elastic load and displacement of the treated polyester reinforced concrete was higher than the untreated polyester reinforced concrete.

In addition, the elastic load and displacement of the PMA-treated polyester reinforced concrete was lower than the PAA-treated polyester reinforced concrete [14] for the reason that PAA is more polar than PMA, which could be more adsolubilized into a bilayer of surfactant and obtained higher hydrophilicity of the fabric surface. The higher hydrophilicity of the fabric surface brought to the stronger adhesion between the polyester fabric and the cement matrix, which gave the higher elastic load and displacement.

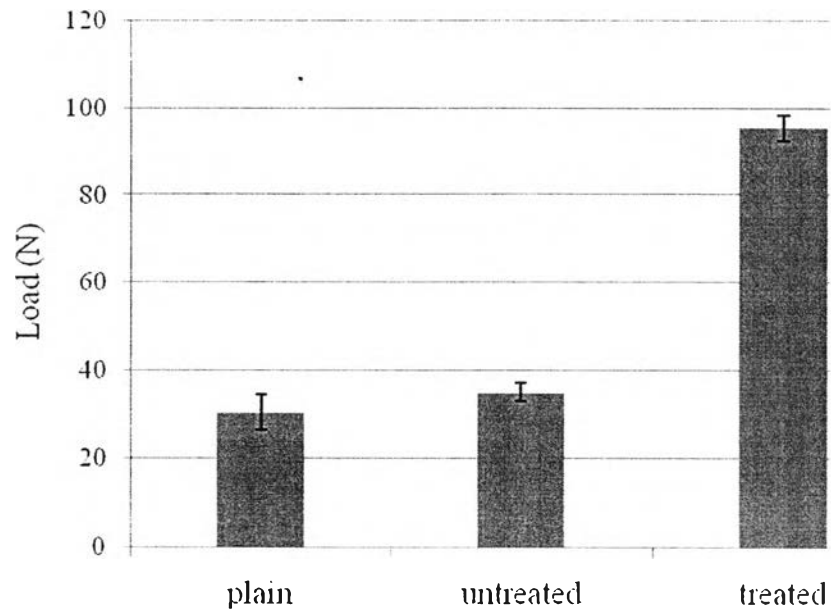


Figure 4.14 The elastic load of plain concrete, untreated and treated polyester reinforced concrete.

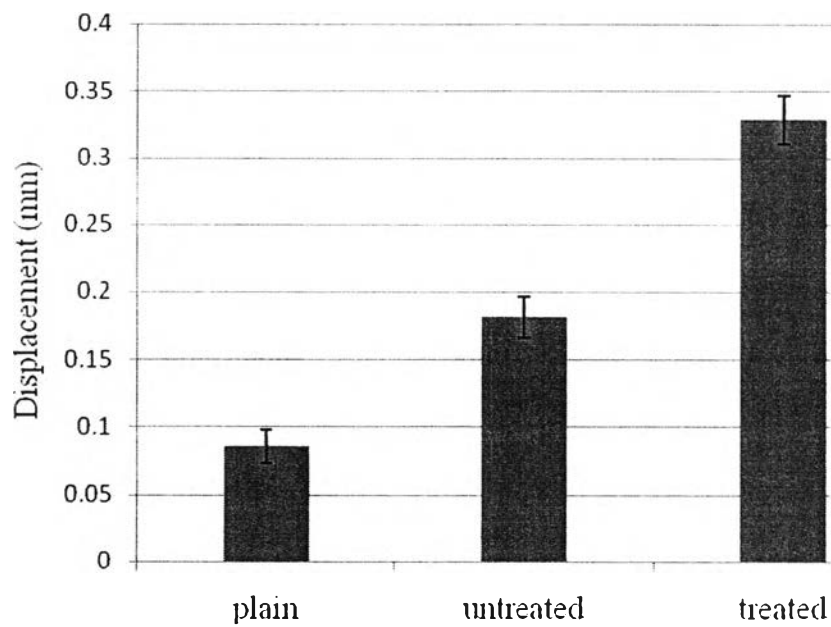


Figure 4.15 The displacement of plain concrete, untreated and treated polyester reinforced concrete.

4.5 Conclusion

Formation of poly(methyl acrylate) film on polyester fabric by admicellar polymerization has been successfully carried out in this work. The optimum conditions for carried out admicellar polymerization of methyl acrylate monomer on polyester fabric which gave polyester surface with highest hydrophilicity is 1.5 mM DBSA, 0.05 M NaCl, 1:2 DBSA:AA ratio, 1:5 AIBN:AA ratio at 75°C. FT-IR spectra and SEM micrographs confirmed that poly(methyl acrylate) thin film was successfully formed on polyester fabric. Hydrophilicity of the PMA-coated fabric as measured by the contact angle was found to decrease when the monomer increased. Ductility of concrete behavior showed that untreated polyester reinforced concrete is more flexural than plain concrete about 210%. Flexural test showed that treated polyester fabric reinforced concrete improved the elastic load and flexural deformation by 270% and 180%, respectively, when compared with untreated polyester reinforced concrete.

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