

Effects of Soft Segments on the Surface Properties of Polydimethylsiloxane Waterborne Polyurethane Prepolymer Blends and Treated Nylon Fabrics

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ABSTRACT: This study of waterborne polyurethane prepolymer blends was done to investigate the effects of different types of soft segments on the dispersion properties and other properties of treated nylon fabrics. The particle size of the dispersion increased, the surface tension of the dispersion decreased, and the contact angle of the nylon fabric with the dispersion decreased when the blending amount of the polydimethylsiloxane polyurethane prepolymer increased. The add-on of ether-type polyurethane increased rapidly when the ether-type polyurethane was blended with a small amount of the polydimethylsiloxane polyurethane prepolymer, whereas the add-on of the ether-type polyurethane reached a maximum at a blending content of

10%. The add-on of the ester-type polyurethane prepolymer constantly decreased with increasing blending amount of the polydimethylsiloxane polyurethane prepolymer. The vertical wicking height of the treated nylon fabrics decreased slightly when the treating agent contained a small amount of the polydimethylsiloxane polyurethane prepolymer. For the treated nylon fabrics with blended prepolymers, the drying time was faster than for the untreated fabric, and the moisture ratio reached about 10% in 15 min © 2009 Wiley Periodicals, Inc. *J Appl Polym Sci* 115: 3550–3558, 2010

Key words: polysiloxanes; polyurethanes; water-soluble polymers

INTRODUCTION

Synthetic fibers possess excellent crystallinity, rigidity, strength, and so on; however, they also have some disadvantages, such as low moisture absorption, static electricity, and low soil repellence. To improve the hydrophilicity and soil resistance of synthetic fibers, it is necessary to proceed with hydrophilic finishing. Previous methods of hydrophilic finishing have mainly included the copolymerization of hydrophilic monomers,¹ combination spinning of hydrophilic ingredients,^{2,3} grafting copolymerization of hydrophilic monomers,^{4,5} fiber cavitation and textile fluffing,^{6,7} changes in fiber composition,^{8,9} and covering or adsorption of hydrophilic resin.^{10–16} In the covering method, hydrophilic resins, such as water-soluble polyester and acrylic or epoxy resins, have been used to make a resin cover on the surface of the fiber by coating and, on the other hand, by dipping to make a resin-absorbed synthetic fabric in the absorption method. Previous studies on hydrophilic finishing agents, for example,

the patent of Lark,¹⁰ indicated that poly(ethylene terephthalate) fabric was absorbed with the hydrophilic polyester, synthesized from acid anhydride, aromatic poly(carboxylic acid), and poly(ethylene glycol) (PEG), by a padding method to improve the hydrophilic properties and the soil repellence of the treated poly(ethylene terephthalate) fabric. Caldwell and Gilkey¹¹ added a hydrophilic polyester, containing ionic groups, carboxyl (–COOH), sulfonic (–SO₃H), or phosphoric (–PO₄H₂), to the padding dispersion and improved the hydrophilic properties and soil resistance of the treated fabric. On the other hand, the acrylic of ultraviolet-curable urethane prepolymer was synthesized from isophorone diisocyanate, 2-hydroxyethyl methacrylate, poly(propylene glycol) (PPG), and different chain extenders to study the influence of the PPG molecular weight on the gas permeability and tear strength of the formative substances.¹³ Covering or adsorption methods improve the hydrophilic properties of finishing fabrics, but the washing durability is still insufficient.

Reactive oligomers, especially urethane prepolymers, are used to offer excellent detergent-washing durability to treated fabrics. Polyurethane (PU) prepolymer is prepared by polymerization of a hard segment of diisocyanate and a soft segment of

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polydiol. The two terminal NCO groups of the PU prepolymer is capped by a blockade agent. The PU prepolymer has been widely applied in the coating and adhesive industries, inks, biological materials, fiber processing, and so forth.^{17–21} The dispersion properties of the PU prepolymer are mainly influenced by the composition of ester- or ether-based soft segments. Furthermore, polydimethylsiloxane (PDMS) offers the advantages of low surface tension, waterproof properties, unique flexibility, low glass-transition temperature, high thermal stability, chemical inertness, and so on.²² In the past, to improve PU properties, many studies introduced PDMS into the PU structure, which resulted in improved mechanical properties and thermal resistance.^{23–25} Our laboratory²⁶ synthesized waterborne PU by either blending with PDMS–PU or copolymerization with PDMS soft segments. Our research showed that, when a small amount of PDMS–PU was blended in waterborne PU, the PDMS segments migrated to the surface of the PU membranes and altered the PU crystallization; this resulted in a significant enhancement of the thermal properties and modulus. Hence, to improve the detergent-washing durability of hydrophilic treated fabric, in this study, we focused mainly on the dispersion properties of reactive PU prepolymers and their blends with PDMS–PU prepolymer and also on the surface properties of nylon treated fabrics padded with PU prepolymer blends.

In this study, dicyclohexylmethane diisocyanate (H_{12} MDI) as a hard segment, 2,2-bis(hydroxymethyl) propionic acid (DMPA) as an ionic center, and different types of soft segments, such as an ester-type polyol [polycaprolactone (PCL)] and an ether-type polyol [PEG, PPG, or poly(tetramethylene glycol) (PTMG)], were used to synthesize ester- and ether-type waterborne polyurethane prepolymers (WPUPs). Then, PDMS was used as a soft segment to synthesize a PDMS–PU prepolymer (S2000). Furthermore, different amounts of S2000 were blended into various kinds of WPUPs to investigate the dispersion properties of neat and blended WPUPs and also the surface properties of nylon treated fabrics.

EXPERIMENTAL

Materials

Poly(ethylene glycol) with a number-average molecular weight of 600 (PEG600; Merck, Darmstadt, Germany), poly(ethylene glycol) with a number-average molecular weight of 1000 (PEG1000; Merck), poly(ethylene glycol) with a number-average molecular weight of 2000 (PEG2000; Merck), poly(propylene glycol) with a number-average molecular weight of 1000 (PPG1000; Merck), poly(tetramethylene glycol) with a number-average molecular weight of 1000 (PTMG1000; Merck), polycaprolactone with a num-

ber-average molecular weight of 1250 (PCL1250; Merck), and hydroxyl-functional polydimethylsiloxane polyoxyethylene (hPDMS; number-average molecular weight = 2000, SF-8427, Dow-Corning, Midland, MI) were used as soft segments of polydiols. In addition to the soft segments of polydiols, H_{12} MDI (Bayer, Leverkusen, Germany) and DMPA (reagent grade, Acros, Geel, Belgium) were used as hard segments and potential ionic centers to synthesize anionic WPUPs. All of the materials were vacuum-dried at 80°C for 2 h. Triethylamine (TEA; reagent grade, Acros), methyl ethyl ketoxime (MEKO; reagent grade, Acros), and 1-methyl-2-pyrrolidone (NMP; reagent grade, Acros), used as a neutralizer, blockade agent, and solvent, respectively, were immersed in 4-Å molecular sieves for more than 1 week and were distilled before use. The nylon fabric of flat weaving was supplied by Formosa Taffeta Co., Ltd. (Touliu, Taiwan).

Synthesis of the PU prepolymer

The anionic WPUP was synthesized by a prepolymer procedure.²⁷ For the synthesis of PU prepolymer, 1 mol of polydiol (PEG, PPG, PTMG, PCL, or PDMS), 1 mol of DMPA dissolved in NMP by heating at 80°C, 4 mol of H_{12} MDI, and the catalyst (di-*n*-butyltin dilaurate) were added. The mixture was allowed to prepolymerize at 90°C for 4 h until the half NCO residue value of H_{12} MDI was reached. The change in the NCO value during prepolymerization was determined with a standard dibutylamine back-titration method.²⁸ The prepolymer was cooled to 70°C and neutralized with TEA. The prepolymer dispersion was obtained by the addition of water and the capping agent with 4 mol of aqueous MEKO for 40 min. The final dispersion was diluted to a 30% aqueous solution. The reactions involved are shown in Scheme 1. The compositions and symbols of the PU prepolymers are listed in Table I. The infrared spectra of the final samples were obtained on a Fourier transform infrared (FTIR) spectrophotometer (Jasco, Tokyo, Japan). Figure 1 shows the FTIR spectra of the PU prepolymers with different soft segments. For the PU prepolymer, absorption bands were found around 3300 cm^{-1} (NH groups, narrow), 1730 cm^{-1} (C=O groups of urethanes), 1690 cm^{-1} (C=O groups of ureas), and 1540 cm^{-1} (–CNH groups).

Preparation of the blend materials

This research used different types of soft segments, such as ester-type polyols (PCL) and ether-type polyols (PEG, PPG, and PTMG), to synthesize various ester- and ether-type WPUPs. Furthermore, we used PDMS as a soft segment to synthesize S2000, which in different content ratios (5, 10, 15, 20, 25, 50,

TABLE I
Symbols and Compositions of Neat WPUPs

| Symbol | Soft-segment composition | | PU composition (wt %) | | | |
|--------|--------------------------|------------------|-----------------------|--------------|-------------------|----------------|
| | Type | Molecular weight | Hard segment | Soft segment | Dispersing center | Blockade agent |
| E600 | PEG | 600 | 49.2 | 28.2 | 6.3 | 16.3 |
| E1000 | PEG | 1000 | 41.4 | 39.5 | 5.3 | 13.8 |
| E2000 | PEG | 2000 | 29.7 | 56.7 | 3.8 | 9.9 |
| P1000 | PPG | 1000 | 41.4 | 39.5 | 5.3 | 13.8 |
| T1000 | PTMG | 1000 | 41.4 | 39.5 | 5.3 | 13.8 |
| C1250 | PCL | 1250 | 37.7 | 45.0 | 4.8 | 12.5 |
| S2000 | PDMS | 2000 | 29.7 | 56.7 | 3.8 | 9.9 |

The hard segment/soft segment/dispersing center/blockade agent molar ratio was 4 : 1 : 1 : 4. The hard segment was H₁₂MDI. The dispersing center was DMPA. The blockade agent was MEKO.

contact angle, which could be measured when the PU prepolymer dispersion contacted the acrylic plate and nylon fabric, was determined with a contact angle meter (FACE CA-5, Tokyo, Japan).

Fabric treatment and testing

The treatment dispersion was composed of the prepolymer at a series of concentrations and a catalyst, CAT32 (0.05% of the prepolymer). A pad-dry-cure process to treat the nylon fabric was carried out sequentially from padding by a one-dip/one-nip method (pickup = 85%) through predrying at 80°C for 5 min followed by curing at 130°C for 3 min. Then, the washing process was done with a sodium carbonate solution of 2 g/L at 60°C for 20 min. We tested the add-on and physical properties of the treated fabric. The washing durability was tested by AATCC 135. The moisture regain, time of drop absorption, and vertical wicking height were tested by the ASTM 629-88, CNS12915 water absorption A (the way of drop-down standard), and CNS12915 water absorption B (Byreck standard) methods, respectively. The fabric samples (10 × 10 cm²) for dry-time testing were dipped in distilled water with the one-dip/one-nip method (pickup = 100%) and then put in the oven of weighing scales at 90°C. We recorded water loss as a weight percentage every 5 min.

RESULTS AND DISCUSSION

Dispersion properties of the neat PU prepolymers

Figure 2 shows the distribution of particle sizes in different PU prepolymer dispersions with a series of different soft segments. There were great differences in the particle sizes of the PU prepolymers, in which the maximal particle size and a wide distribution of S2000, ranging from 1.5 to 6.0 μm were observed; on the contrary, the minimal particle size and a narrow distribution, ranging from 0.4 to 1.2 μm, were

observed for the PEG2000-PU prepolymer (E2000). In general, hydrophilic PU prepolymers are obviously different from hydrophobic PU prepolymers; for example, the former have smaller particle sizes and a narrow distributions. whereas the latter series

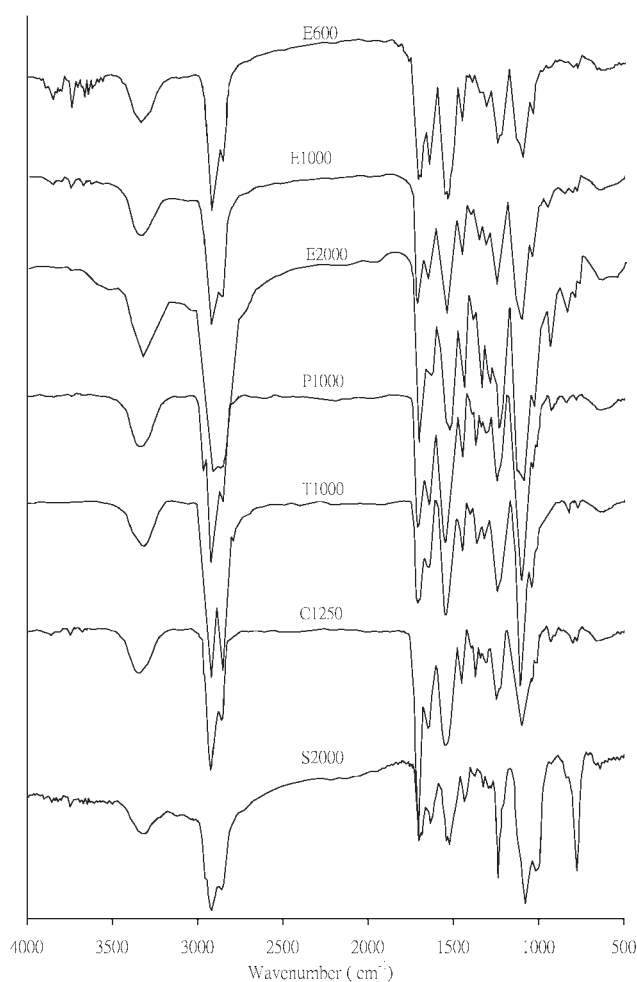


Figure 1 FTIR spectra of the neat WPUPs from different soft-segment types.

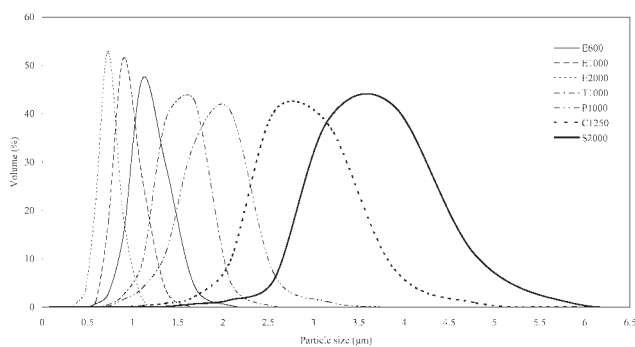


Figure 2 Particle size distribution of the neat WPUP dispersions from different soft segments.

have the opposite properties. With the statistics formulas shown in Table II, the average particle size and variance of the particle size of various kinds of PU prepolymer dispersions were calculated by the volume of particle sizes and the particle sizes, and the data are shown in Table II.

In terms of the various soft segments of the same molecular weight, the PEG1000–PU prepolymer (E1000) had the smallest average particle size and variance, and the PTMG1000–PU prepolymer (T1000), PPG1000–PU prepolymer (P1000), PCL1250–PU prepolymer (C1250), and S2000 followed by increasing order. A high-hydrophilic PEG soft segment in E1000 made it easy to dissolve in water. A PTMG soft segment in T1000 was more hydrophobic and gave the larger particle size. The PPG soft segment with methyl groups in the side chain in P1000 caused its particle size to be larger than E1000 and T1000. The ester-type PCL soft segment in C1250 was more hydrophobic than those of all of the others except S2000, which made it easy to aggregate in water and led to its larger particle size. S2000 did not disperse in water easily because of its low polarity; hence, its particle size was the largest. Moreover,

TABLE II
Dispersion Properties and Surface Properties of Neat WPUPs from Different Soft Segments

| Symbol | \bar{S} (µm) ^a | D^b | Surface tension (dyne/cm) | Contact angle (°) | |
|--------|-----------------------------|-------|---------------------------|--------------------------------|----------------------------|
| | | | | Dispersion on an acrylic plate | Dispersion on nylon fabric |
| E600 | 1.17 | 1.10 | 55.9 | 69 | 109 |
| E1000 | 0.94 | 0.98 | 58.0 | 77 | 112 |
| E2000 | 0.73 | 0.86 | 58.8 | 80 | 116 |
| P1000 | 1.85 | 1.39 | 52.1 | 67 | 106 |
| T1000 | 1.51 | 1.25 | 60.7 | 75 | 107 |
| C1250 | 2.83 | 1.71 | 54.6 | 62 | 100 |
| S2000 | 3.61 | 1.93 | 45.7 | 58 | 61 |

D = variance of particle size; S = particle size; \bar{S} = average particle size; V = volume.

$$^a \bar{S} = \frac{\sum(V \times S)}{\sum V}$$

$$^b D = \sqrt{\frac{\sum[V \times (S - \bar{S})^2]}{\sum V}}$$

as the molecular weight of the PEG soft segment increased, the average particle size decreased in the E-type dispersion. Because PEG is a hydrophilic soft segment, the PEG2000 soft segment in E2000 had a larger content of hydrophilic groups; this led to difficult aggregation in water.

Figure 3 shows the surface tension of the PU prepolymer dispersions; the critical micelle concentration of all of the PU prepolymers was approximately 0.01%. The PU prepolymers of different soft segments had a large variation in the surface tension, and the results are shown in Table II. As shown in Table II, in terms of the soft-segment type, the highest surface tension belonged to T1000, and the surface tensions of E1000, C1250, and P1000 were in decreasing order; the lowest belonged to S2000. The surface tension is related to the alignment of the substance on the interface. PDMS belonged to the nonpolar soft segment, in which S2000 tended to be aligned on the surface of the dispersion and reduced its surface tension greatly. P1000, with the side chain of methyl groups, aggregated with difficulty and tended to be easily aligned on the surface of the dispersion; therefore, its surface tension was the second lowest. The hydrophobic C1250 tended to be easily aligned on the surface of the dispersion, so the surface tension was also low. E1000 and T1000 both belonged to hydrophilic PU prepolymers, but T1000, with higher flexibility, was not easy to align on the surface;²⁹ thus, it had the highest surface tension. In addition, with respect to the molecular weight of the PEG soft segment, the surface tension of E2000 was higher than those of E1000 and E600. The PU prepolymer with the longer PEG soft segment had a strong hydrophilicity, so it was not easily aligned on the surface of the dispersion, and therefore, the surface tension was high.

Table II also shows the contact angles of the PU prepolymer dispersions on the acrylic plate and nylon fabrics. The trends in the two kinds of contact angles were similar. In the different series of soft

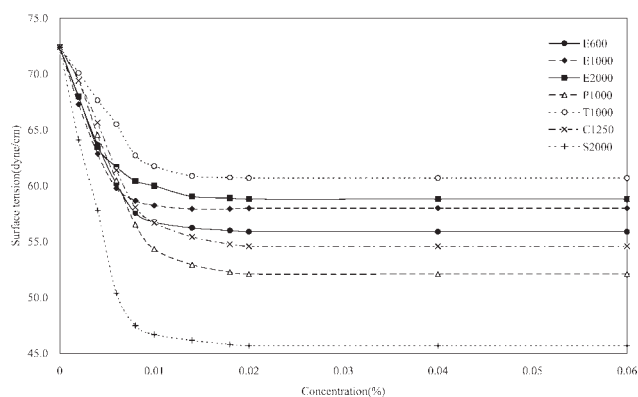


Figure 3 Surface tension of the neat WPUP dispersions.

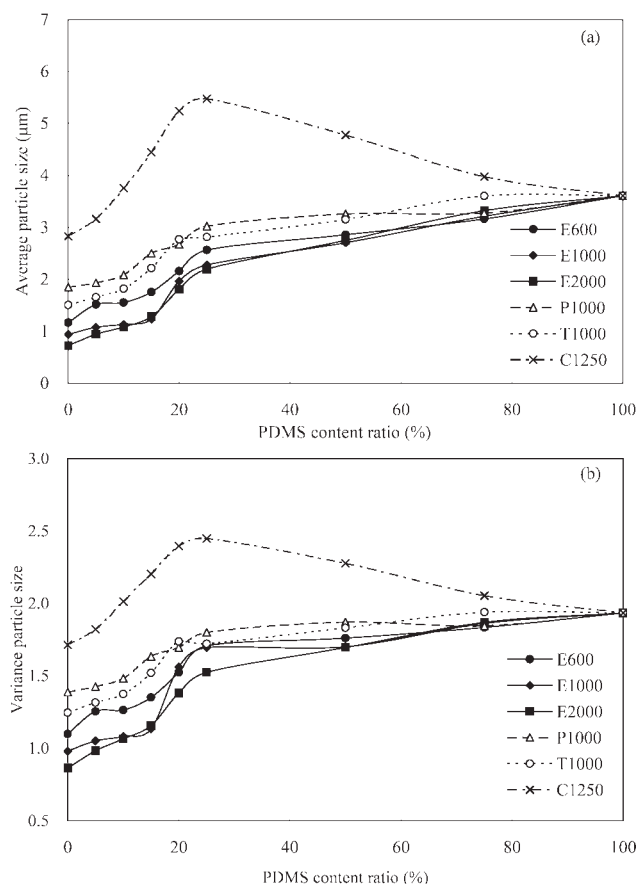


Figure 4 Comparison of the (a) average particle size and (b) variance of the particle size of the WPUP blends.

segments, E1000 had the largest contact angle, and the others with smaller contact angles were T1000, P1000, C1250, and S2000 in order, with S2000 being the smallest. The results of the contact angles are reverse those of the particle size. In the group of different molecular weights of PEG soft segments, E2000 had the largest contact angle, E1000 had second largest, and E600 had the smallest. This was also related to the hydrophilicity of the PU prepolymer. Because the nylon was hydrophobic, it was difficult to dampen, which resulted in a larger contact angle.

Dispersion properties of various WPUPs blended with S2000

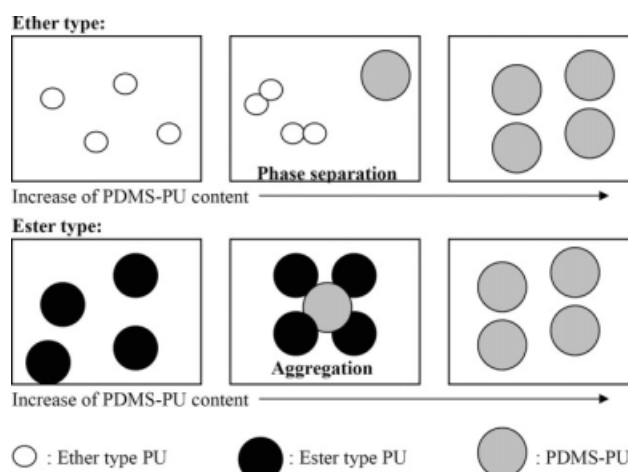
Figure 4 shows the comparison of the average particle size and the variance of the particle size in the dispersion of PU prepolymers, which had different series of soft segments blended with different amounts of S2000. In terms of average particle size in Figure 4(a), no matter which kind of PU prepolymers were used, the particle size of dispersion increased with increasing blending amount of S2000. The particle size of the ester-type PU prepolymer (C1250) was larger than that of the ether type. More-

over, at a blending amount of 25%, the particle size of the ester-type PU prepolymer declined, and that of the ether series also increased gradually. With an increase of S2000 content, both the ether-type PUs and S2000 formed phase separation; however, the phase changed as the blending amount approached 25%. In addition, both C1250 and S2000 belonged to hydrophobic PU prepolymers; hence, the blending of S2000 increased the aggregation of inter C1250 and S2000. The phase morphology is shown in Scheme 2. Compared with the various particle sizes of the WPUP blends, the particle size of the E2000 series was the smallest and that of C1250 was the largest, whereas those of E1000, T1000, E600, and P1000 were ranked between E2000 and C1250, respectively. The three PEG series of WPUP blends also had similar trends of particle size.

Figure 4(b) compares the variance of the particle size of the WPUP dispersion blends of different soft segments. The distribution curves represented a uniform degree of particle size. The variance of the particle size of different WPUPs blended with S2000 showed similar results as those of average particle size.

Figure 5 shows the comparison of the surface tensions of the WPUP dispersions that had different soft segments blended with S2000. As shown in Figure 5, the T1000 series had the highest surface tension, and the others had lower surface tensions in the order E2000, E1000, E600, C1250, and P1000, with the smallest surface tension. These results were the same as those of the neat PU prepolymers. In addition, the increase in S2000 content enhanced the surface content of nonpolar PDMS and caused a decrease in the surface tension.

The trends of contact angle for the WPUP blends on acrylic plates and nylon fabrics were approximately similar. Figure 6 shows a comparison of the contact angles for WPUP blends on the nylon fabrics. With an increase in S2000 content, the contact



Scheme 2 Relative amount of PDMS-PU in the blends.

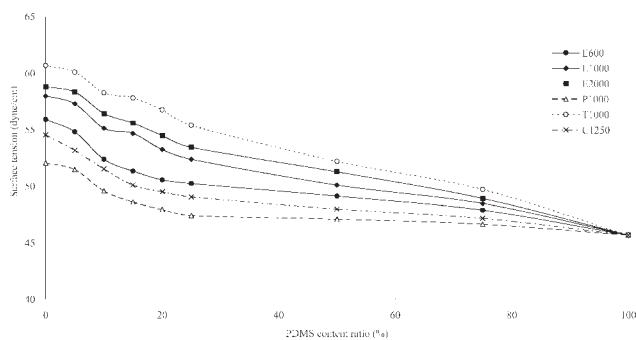


Figure 5 Comparison of the surface tension of the WPUP blends from different soft segments.

angles of various WPUPs on the nylon fabrics decreased, whereas the contact angle decreased gradually at a 25% blending amount.

Surface properties of the nylon fabrics treated with various WPUPs blended with S2000

Figure 7 shows the influence of WPUPs with different soft segments and their blending amounts with S2000 on the add-on and durability of treated nylon fabrics. In terms of add-on before washing shown in Figure 7(a), among various soft segments with the same molecular weight, E1000 had the smallest add-on of the neat WPUPs, and T1000, P1000, and C1250 had add-ons in increasing order. In addition, with respect to the molecular weight of the PEG soft segment, the smallest add-on of the treated nylon fabric was E2000, whereas the medium add-on was E1000, and the largest was E600. The results were in reverse order of the contact angle of the nylon fabrics with WPUPs. In other words, the add-ons of the treated fabrics were affected by the hydrophilicity of the soft segment (PCL), so when the contact angle of the WPUP dispersion was higher, the add-on of the treated fabric was smaller. Furthermore, in the aspect of the fabrics treated by the blending of WPUPs, the add-on of ether-type WPUP increased rapidly when it was blended with a small amount of S2000, reached a maximum at a blending content of 10%, and then

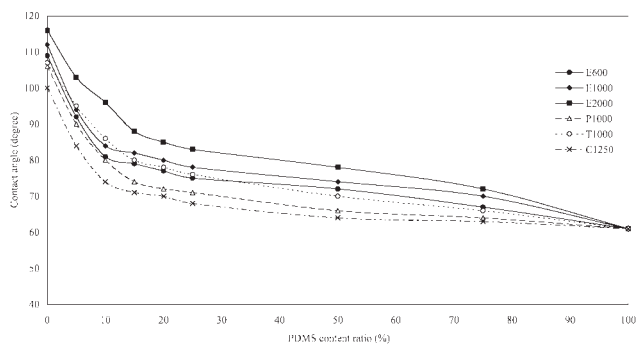


Figure 6 Comparison of the contact angles for the WPUP blends on the nylon fabrics.

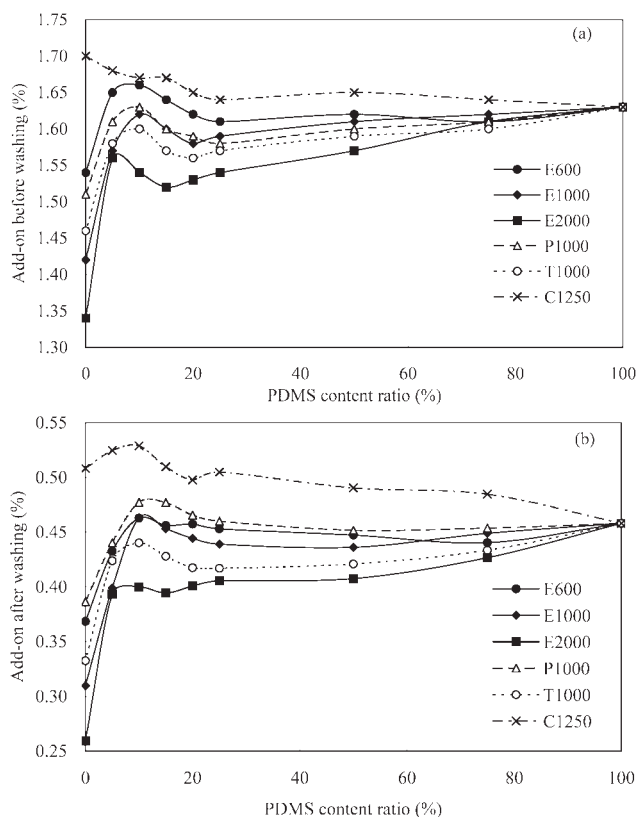


Figure 7 Add-ons (a) before washing and (b) after washing for WPUP blends on the treated nylon fabrics.

decreased slightly to approach equilibrium. When the ether-type WPUP dispersion was blended with a small amount of S2000, the decrease in surface tension led to a reduction in the contact angle of the nylon fabric with WPUP dispersion (in Fig. 6) and facilitated the affinity of WPUP on the fabric. Nevertheless, above a 10% blending amount, the add-on decreased, which may have been due to the gradual decrease of the contact angle of the nylon fabric with WPUP dispersion, but the particle size of the blended WPUPs increased greatly (in Fig. 4), which made it difficult to absorb into the interfibers. On the other hand, the ester-type WPUP constantly decreased with increasing blending amount of S2000 because the particle size of the PCL-PU blend increased sharply. The particle size of the PCL-PU blend was still larger, although the particle size of the blend decreased above the 25% blending amount (in Fig. 4) and led to a difficulty of diffusion into the interfibers. Figure 7(b) shows the influence of the add-on after the washing of the treated nylon fabrics, which signifies the washing durability of the treated fabrics. The results shown in Figure 7(b) are approximately the same as those shown in Figure 7(a), and this suggests that the washing durability increased with better affinity of the nylon fabric to the WPUP. Furthermore, PDMS, which provided the effect of changing

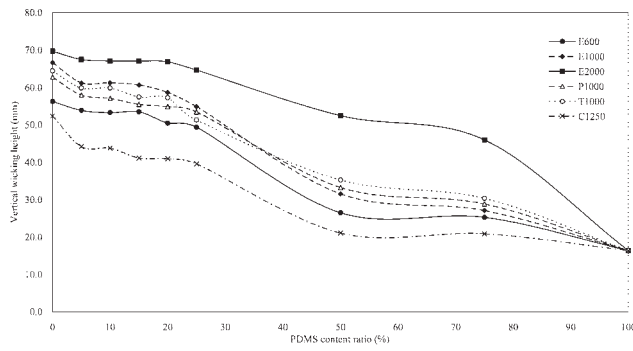


Figure 8 Vertical wicking height and PDMS content ratio for the treated nylon fabrics.

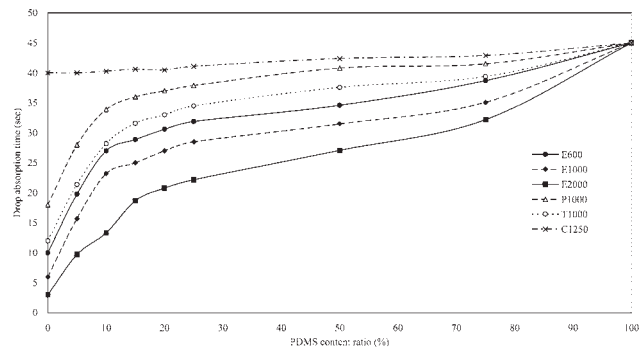


Figure 9 Drop absorption time and PDMS content ratio for the treated nylon fabrics.

the surface properties, offered the advantage of low surface tension and waterproof properties.²² The washing durability could have been improved with a small amount of blended S2000.

Figure 8 shows the influence of blending with S2000 on the vertical wicking height of the treated nylon fabrics. When the WPUP dispersion was blended with a low content of S2000, a slight decrease in the vertical wicking height was found. The vertical wicking height was not reduced when there was a great increase in the treated fabric's add-on, and it remained the same for the levels of neat WPUPs. Above a 20% blending amount, the vertical wicking height decreased greatly and approached the level of the treated fabric of neat S2000. This observation was related to the hydrophilicity of the group in the PU structure; the higher the amount of the S2000 was, the higher the hydrophobicity of the group in the PU structure was. In terms of various kinds of PU prepolymers, their vertical wicking heights in the treated fabrics were in the order C1250 < P1000 < T1000 < E1000. Furthermore, for the various molecular weights of the PEG soft segments, the order of vertical wicking height was E600 < E1000 < E2000, which was reverse that of the particle size. The vertical wicking height of the treated fabrics was affected by the hydrophilicity of the WPUP. The higher hydrophilicity of treated fabric facilitated the moisture transport of the capillary.

Figure 9 shows the influence of different series of WPUPs blended with different amounts of S2000 on the drop absorption time of the treated nylon fabrics. The figure shows that, except for the hydrophobic C1250 series, the drop absorption time of the treated fabrics increased with increasing S2000 content, and it increased sharply when the content of S2000 blending was low (5–10%). When the ether-type series was blended with a low content of S2000, the migration of PDMS to the surface formed a membrane, which led to a hydrophobic surface-treated fabric that was PDMS-rich; hence, it was not easy to

keep it moist. These results are related to the contact angle of the nylon fabrics with WPUP dispersion.

Figure 10(a) shows the influence of various kinds of neat WPUPs on the drying times of the treated nylon fabrics. The fabrics for drying time testing samples were dipped into distilled water by the one-dip/one-nip method (pickup = 100%) under the same value of moisture content. The treated fabrics of neat S2000 had the shortest drying time. Except for S2000 and C1250, the drying times of the nylon fabrics treated with various kinds of WPUPs were slower than that of the untreated fabric. Compared

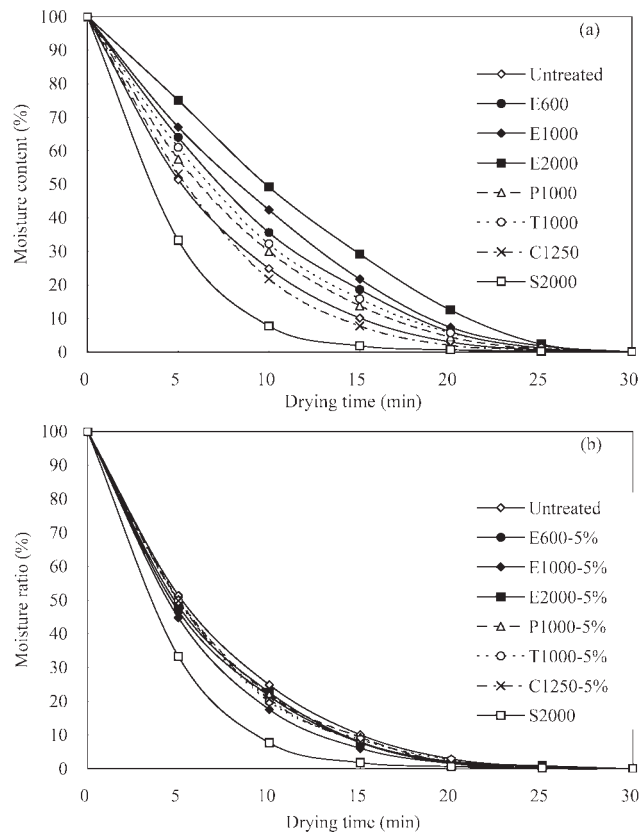


Figure 10 Moisture ratio and drying time at 90°C for the treated nylon fabrics with (a) neat WPUPs and (b) WPUP blends.

with WPUPs of different soft segments, the speed of drying had a trend of C1250 > P1000 > T1000 > E1000. C1250 belonged to the hydrophobic WPUPs, so its drying time was the shortest. The structure of P1000 had methyl groups in the side chain, which caused a larger intermolecular distance, which resulted in a tendency to keep uncombined water. Therefore, its drying time was ranked as second place. The drying times of the hydrophilic T1000 and E1000 were the longest. In terms of the PEG series, the drying times had a trend of E600 > E1000 > E2000. The higher the molecular weight of the soft segment was, the larger the number of hydrophilic ether groups was and the larger number of seats were received to combine water. The higher the hydrophilicity was, the easier it was to produce intermolecular combined water, which was difficult to lose. Figure 10(b) shows the influence of the blending of 5% S2000 on the drying time of the treated nylon fabrics. For all of the treated fabrics with blended WPUPs, the drying time was shorter than for the untreated fabric, and the moisture ratio reached about 10% in 15 min because of the surface migration properties of PDMS, which led to hydrophobic S2000 on the fabric surface. The inner hydrophilic PU absorbed moisture, and then, the moisture was transported to the surface of PDMS, so the moisture evaporated easily.

CONCLUSIONS

This study focused on the dispersion properties of reactive WPUPs and their blends with S2000 and also on the properties of nylon fabrics treated with the WPUP blends. The major findings are summarized as follows:

1. For the neat WPUPs of various soft segments, the higher hydrophilicity of the WPUP dispersion led to a smaller particle size. The highest surface tension was found for T1000 of the ether type, and the order of contact angles was reverse that of the particle sizes.
2. The particle sizes of all of the WPUP dispersions increased, whereas the surface tension of the dispersions decreased and the contact angle of the nylon fabrics with the dispersions decreased when the blending amount of S2000 increased.
3. For the add-ons of the fabrics treated with the WPUP blends, the add-on of the ether-type WPUP increased rapidly when ether WPUP was blended with a small amount of S2000, whereas the add-on of the ether-type WPUP reached a maximum at a blending content of 10%. Above a 10% blending ratio, the add-on of the ether-type WPUP slightly decreased until it reached the level of neat S2000. Nevertheless, the add-on of the ester-type WPUP constantly decreased with increasing blending amount of S2000.
4. When the treated fabrics contained a low content of S2000, the vertical wicking height of the treated fabrics decreased slightly and retained the levels of neat WPUPs. Except for the hydrophobic C1250 series, the drop absorption time of the treated fabrics increased with increasing S2000 content. It increased greatly and immediately when the content of S2000 blending was low (5–10%).
5. For the treated nylon fabrics with blended WPUPs, the drying time was faster than for the untreated fabric, and the moisture ratio reached about 10% in 15 min.

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