NONWOVEN FABRICS FROM BLENDS OF GREIGE COTTON AND RECYCLED POLYESTER

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Abstract

Greige cotton fibers and recycled polyester waste fibers were used to produce low-cost, nonwoven blanket materials that were comfortable, provided thermal insulation, and maintained an acceptable appearance through short-term laundering. Waste polyester remnants are available through a recently developed commercial process. Greige cotton, rather than scoured and bleached, was chosen to blend with the short reprocessed polyester because it is environmentally acceptable, and the longer fibers provide strength and stability. Various blend ratios were examined. Chemical finishes were applied to the fabrics to enhance properties, and physical and thermal properties of the fabrics were measured.

Introduction

The textile industry provides ideal opportunities for developing technology for the use of recycled, reprocessed, or low grade fibers to produce environmentally acceptable textile products. The definition of "environmentally improved textile products (ETIP)" as provided by the American Textile Manufacturers Institute (ATMI) includes the use of recycled or reprocessed fibers, as well as unbleached or undyed products (American Textile, 1995). Many areas of textile processing for both garments and household goods produce waste materials that can be recycled into usable consumer products. More than 400 million pounds of non-biodegradable polyester remnants are produced as waste each year (Wallick, 1999). Such waste provide good sources of materials for recycled products. In addition, most commercial cotton textile processes require that the fibers be scoured and bleached. Use of greige cotton in consumer products would not only reduce production costs, but would eliminate the discharge of chemicals needed in the scouring and bleaching process.

A new process has recently been developed for separating polyester remnants into open, blendable fibers (Wallick, 1999). In this work cotton has been blended with this recycled polyester fiber product to produce a nonwoven blanket material. Nonwoven processes can better utilize the short reprocessed polyester fibers, and are more economical than woven or knit processes. The intent was to produce a semi-disposable blanket material that would be efficient yet of low enough cost that it could be used in short-term or emergency situations, for military or recreational uses, laundered through several cycles and finally disposed.

Materials and Methods

Fabrics

Cotton and polyester fibers were opened separately and blended on an opener (SpinLab) before carding. Batts were prepared from reprocessed polyester and cotton using a card (Whitin) equipped with plates (Cardmaster). The doffer-roll speed was approximately 11.3 rpm, and the cylinder speed was approximately 198 rpm. The batts were reinforced with a spun-bonded nylon scrim (0.5 oz/yd^2) for greater integrity. They were then needlepunched four times on a needle loom (Morrison Berkshire) equipped with a single 31.8 cm board containing 575 needles. The needle design was 15x18x40x3.5 (F222-G92919, Groz-Beckert). Batts were processed into nonwovens at a linear speed of 3.5 ft/min, 250 penetrations/in^2, and 230 strokes/min. Blends of 70/30, 60/40, and 50/50 polyester/cotton were made. Weight of fabrics averaged 10 oz/yd^2, and thickness was approximately 0.2 in.

Fabrics used in the study included 70/30, 60/40, and 50/50 polyester/ cotton blends of the following samples:

- C-cotton/polyester, no finish
- C5- cotton/polyester, no finish, laundered 5 cycles
- CX-cotton/polyester, carboxylic acid finish
- CX5-cotton/ polyester, carboxylic acid finish, laundered 5 cycles
- CXA-cotton/polyester, carboxylic acid and antibacterial finish
- CXA5-cotton/polyester, carboxylic acid and antibacterial finish, laundered 5 cycles

Commercial nonwoven blankets including a 100% virgin acrylic (A), a 100% virgin polyester (P), a recycled polyester yarn (RP), and a recycled wool blend (W) blanket were used for comparison in testing of the experimental blankets. These blankets were laundered as was the experimental blanket.

Finishing

Fabrics were finished for stability and enhanced flame resistance using a pad-dry-cure process with citric and tartaric acid (Welch). They were also finished with an antibacterial agent for uses where this application would be advantageous (Vigo). These finishes were formulated specifically for the blended nonwoven fabrics in this work (Goynes).

Physical Properties

Air permeability, thickness, weight, and stiffness were measured to identify differences in properties related to the

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hand of the blankets. Tensile strength and flammability tests were done to examine the blanket integrity.

Thermal conductivity and transmission tests were performed using a LaserComp thermal conductivity meter, FOX 200, in accordance with ASTM D1518- 85 standard procedure. Samples (8"x 8") were placed between two plates, "cold"[T_{cp} = 21.0 °C; (68.9˚F)] and "hot" [T_{hp} = 36.6 °C**;** (97.9 ˚F)]. The average of three samples with triple measurement for each sample was used to calculate the mean values of the thermal conductivity and thermal transmittance for each blanket specimen.

Results and Discussion

Nonwovens that were prepared in this study were intended for determining whether greige cotton and short, recycled polyester fibers can be blended into a nonwoven fabric suitable for short-term use as thermal blankets. For this purpose they need to be comfortable, flame resistant, durable through a short number of laundry cycles (5), antimicrobial where applicable, and to provide thermal insulation.

Although the materials were finished with carboxylic acid crosslinking agents, this finish was not intended to improve wrinkle resistance but to enhance flame resistance and to stabilize the fibers within the fabric structure in order to reduce pilling during use or laundering. Use of cotton in the blended fabric allowed application of these previously developed finishes for cotton in the blended fabrics.

Results from laundering and flame resistance tests showed that the carboxylic acid finish did improve flame resistance as well as the stability of the fibers within the fabric. When the unfinished experimental fabric was laundered five times, the fabric surface became rough because of pilling. The matted fibers often formed elongated bundles of fibers on fabric surfaces.

Scanning electron micrographs (SEM) of fabric surfaces showed the unlaundered sample surface to be smooth, but after laundering, matted fiber bundles were present. Crosslinking significantly reduced the amount of pilling and matting on the fabric surface after laundering. Differences in surface appearance of the unlaundered samples and the laundered, crosslinked sample were insignificant. SEM examinations of laundered, crosslinked fabrics from all three cotton/ polyester blends showed little evidence of fiber matting on surfaces.

No specific flame resistance codes for nonwoven blankets were available. Therefore, general codes for blankets were followed. For the test, ignition time was five seconds and the time to burn five inches in a 45-degree flammability tester was recorded. With the exception of private residences, in which the code suggests a class 2 requirement, blankets for public use should meet a class 1 requirement. The classifications for burn times are: Class 1, greater than 20 seconds, Class 2, between 8 and 19 seconds, Class 3, less than 8 seconds. In evaluating these experimental samples,even untreated blanket materials met Class 1 standards. The carboxylic acid finish improved flame resistance of the treated blankets over those that were untreated. The burn times after washing were very similar to the burn times prior to washing. The antibacterial finish unexpectedly produced significant increases in burn times for all samples. This effect was reduced after laundering, but even the laundered samples had longer burn times than the unfinished controls. The commercially available acrylic (A) blanket had an average burn time of 22.5 s. and the commercially available polyester (P) blanket had an average burn time of 33.2s. The 100% recycled polyester yarn (RP) blanket had an average burn time of 26.6s. The test results indicated that the cotton/recycled polyester blankets meet the NFPA 702 requirements for blankets, and the chemical finishes enhance the flame resistance of the samples.

Antibacterial finishes were developed for applications where this property may be important. Treated and untreated fabrics, before and after 5 launderings, were tested commercially for inhibition of representative Gram positive and Gram negative bacterial growth. Untreated samples did not prevent bacterial growth. Treated samples were both antibacterial and bacteriocidal. Laundering through five cycles reduced the effectiveness of the finish, and samples remained antibacterial to Gram positive bacteria only. Higher amounts of cotton increased effectiveness as a Gram positive growth inhibitor on the sample substrate.

Thermal qualities of these blanket materials were of prime importance, and were evaluated using thermal conductivity and transmission measurements. All experimental samples were compared using these tests. Thermal transmittance varies with thickness, therefore values change slightly with each finishing and laundering procedure. However, the transmittance value for the final fabric that had undergone both crosslinking and antibacterial finishing, as well as five launderings was not significantly different from the control fabric. Thermal conductivity decreased after finishing and laundering, indicating better insulative properties. All experimental samples provides 20-30% greater thermal protection than commercially available blankets.

The results of the touch panel tests indicated that the cotton/polyester blended fabrics had better comfort characteristics than did the commercial synthetic and wool blends. Cotton blend fabrics were rated as less harsh, less rough, less scratchy and softer than the commercial control blankets.

Conclusions

Nonwoven blanket materials have been made from blends of recycled polyester fibers and greige cotton. Blending of cotton fibers into these nonwovens allows application of finishes previously developed for cotton fabrics. A nonwoven fabric structure was chosen because nonwovens are less expensive to produce than are wovens or knits, and because the short reprocessed polyester fibers could better be utilized in nonwoven processes. A crosslinking finish increased stability of fibers within the fabric, and also enhanced flame resistance. Finished fabrics withstood five laundry cycles without losing acceptable appearance or structural integrity. An antibacterial finish provided protection on unlaundered samples, but lost effectiveness as laundering progressed. Higher cotton content improved antibacterial effectiveness. The fabrics were light weight, had good hand, and excellent comfort and thermal qualities. These materials would provide highly acceptable thermal coverings for refugee, medical, military, and recreational uses where a low-cost, short-term-use product is desired.

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