COTTON-FACED NONWOVENS FOR SHORT-WEAR-CYCLE TEXTILE APPAREL PRODUCTS

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Abstract

Cotton-faced Nonwovens have been developed with cotton on one side or both sides of a core structure in which the cotton content varies from 41-75% of the fabric weight. The thermally bonded two or three layered laminates are soft, but strong and have a hand similar to cotton knits or hydroentangled fabrics. The fabrics have also demonstrated excellent wetting, wicking rates, water absorption and water retention properties. Although these novel fabrics have notable flexibility and extensibility as produced, a post-treatment process provides the fabrics with instantaneous elastic recoveries ranging from 83-93% from an extension of 50%. The fabrics exhibit minimal linting characteristics and would be suitable as medical isolation gowns, head cover and shoe covers, bed sheets, pillow cases and for consumer applications such as disposable underwear, towels, wipers and personal hygiene products.

Background

Disposable nonwovens entered the medical field over four decades ago, beginning with basic paper-like face masks and proceeding through sterilization wrap and specialty drapes and gowns to become close to a $2.5 billion market. These medical nonwovens have proven to be invaluable in products ranging from drape sheets to surgical gowns to adult pads and underpads by utilizing a gamut of nonwoven structures. The combining of nonwoven technologies has enabled the industry to offer products with properties hitherto though impossible.

The ease of tailoring nonwovens for specific end uses has facilitated greater convenience in storage and identification, leading to savings benefits in equipment, labor and inventory. Further savings are provided by the energy that may be recycled from incineration of the medical waste. Forecasting of needs has also improved since it is simpler to monitor used products [Champault, 1987].

Nonwovens now have almost complete acceptance in U.S. hospitals for applications such as surgical caps, masks and shoe covers and 90-100% penetration in operating room usage has resulted because nonwovens provide relatively inexpensive, lightweight and effective protection [Wadsworth, et. al., 1994]. Nonwovens have now out paced wovens in uses such as surgical gowns and drapes, wherein they have about 60-70% share of the market. With the majority of the medical community being convinced that nonwoven disposables give double benefits of superior barrier protection and ease of use, it is only the psychological barrier that needs to be overcome before nonwovens achieve 80-90% penetration in the operating room market.

Now that cotton has successfully re-established itself as a major fiber in the conventional textile market, it is believed that the nonwovens field will also experience a resurgence of interest for it beyond the original use of cotton linters and waste fibers in nonwovens. With the possible exception of hydro-entangled fabrics, which are produced by an energy intensive and relatively expensive process, nonwovens lack the strength, aesthetics, and comfort of woven and knitted fabrics. Cotton's probability for growth in nonwovens should be high because there are very few products making use of cotton and it has a great potential in end use markets such as medical/surgical products and sanitary products.

Cotton by virtue of its unusual chemistry and structure offers a set of properties including high tensile strength, exceptional absorbency, highly efficient wicking, natural resistance to electrostatic charge build-up, excellent heat resistance and good processability, all of which are important to the manufacture and performance of medical and health care products. Cotton is now economically available because of innovations being introduced by Cotton Incorporated and cotton suppliers, such as continuous scouring and bleaching processes. Suppliers have also improved the processability of cotton to meet the stringent requirements of nonwovens manufacturers not just by increasing the openness of the fiber, but also by improving types of finishes available, the application of finish and consistency of quality from lot to lot. This has made cotton extremely versatile in terms of processability and has made it possible to be used in most of the nonwoven processes, with only processes requiring thermoplasticity such as melt extrusion being exceptions.

Preliminary research was performed at the Textiles and Nonwovens Development Center (TANDEC) at the University of Tennessee to develop laminates containing bleached carded cotton cores with outer layers of melt blown (MB) webs (meltblown/cotton/meltblown or MCM laminates). The MB webs serve as binder fiber materials during the subsequent thermal point bonding step and together with the cotton fibers impart both strength and barrier properties to the laminates. U.S. Patent No. 5,683,794 was issued on November 4, 1997 to The University of Tennessee Research Corporation embodying concepts of cotton core laminates employing a range of nonwoven outer layers with the inventors being L. C. Wadsworth, K.E. Duckett and V. Balasubramanian. The cotton core laminates were developed for applications such

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absorbent pads, towels and wipes, sanitary napkins, diapers, wound dressings and when treated with a repellent finish may also be used for protective apparel such as surgical drapes and gowns.

In applications where greater strength is required, spunbond webs are used on one side in place of MB webs to produce spunbond/cotton/melt blown (SCM) laminates. When no barrier performance of the laminates is required, spunbond webs are placed on both sides to produce SMS laminates. Although cotton serves efficiently as an absorbent core, these laminates still lack the aesthetics that could be attained if cotton was on the surface. However, these researches found it is extremely difficult to produce thermally bonded laminates of cotton/spunbond (CS) or cotton/spunbond/cotton (CSC) laminates, because the cotton fibers in unbonded or loosely bonded webs could not efficiently transfer heat to the inner spunbond (SB) or meltblown (MB) webs, and instead the cotton fibers would wrap around the steel thermal calender rolls. Another drawback of the thermally bonded MCM, SCM, and SCS laminates was their lack of extensibility. However, it was demonstrated that they could be subsequently made elastic by subjecting them to a controlled heating and stretching process invented by Hassenboehler and Wadsworth [Wadsworth, Hassenboehler, 1994, 1997 and 1996].

Nevertheless, it was desirable to produce in one step a laminate with cotton on one or both surfaces, which also had a degree of extensibility. Thus, it was proposed by L. C. Wadsworth and H. C. Allen that it may also be possible to achieve strength in laminates by laying webs containing loosely bonded cotton fibers to one side or both sides of unbonded spunbond webs so that the cotton fibers could " sink" into the open space between the unbonded SB filaments. This would better entrap the cotton fibers between SB filaments so that thermal bonding in the calender tip would tie the cotton fibers down and render them less likely pull out or lint. In addition, the thermally bonded fabric would have much more flexibility and strength than if pre-bonded SB laminates were utilized to prepare the thermally bonded laminates. It was also noted that if the thermally bonded cotton (TC) and SB webs were not stretchable enough, they could be subsequently subjected to the "consolidation" (heating and stretching) processing developed at TANDEC [Hassenboehler, Wadworth, 1995, 1997].

Experimental

A trial was made to fabricate cotton and SB laminates on the SB line. Two types of cotton nonwoven fabrics were used: 100% cotton chemical bond fabric and thermal bonded 60% cotton/40% polypropylene fabrics. While producing the SB web, the cotton fabrics were feed into the calender at the end of the spunbond line; both were passed through the calender (Figure 1). The chemical bonded webs did not bond to the spunbond, but the thermal bonded fabrics did. This allows for on-line production of a cotton-spunbond laminate, which can be used as the base fabric to produce a stretchable fabric. Seven laminates were produced using this method (see Table 1). It should be noted that samples #2 (SB2-TCPP1) and #3 (TCPP1-SB2) have the same composition, except that during the thermal laminating step, the SB web was placed on top in #2 so that it contacted the upper steel diamond heated roller. On the other hand, in the sample #3 the SB web was against the lower smooth steel heated roller. SEM photographs clearly show the fabrics (1-5) containing two layers are bonded to each other at the bonding points, with sample #1, which contained the heavier weight spunbond, having a more defined bond (Figure 2). The three layered sample #6 also containing the heavier spunbond web, was observed by SEM to have clear bonding points (Figure 3). The SEM of other three layered laminates #7 showed the outer layers were not bonded with the center layer (Figure 4).

Although these fabrics had notably more extensibility than could have been obtained by laminating the outer cotton nonwovens to pre-bonded SB fabrics, it was believed that their stretchability could be substantially improved by subjecting them to the TANDEC "Web Consolidation" process. Thus these fabrics were post-treated by the process, which heats the fabric while it is being drafted in the machine direction (MD) or conversely, while the fabric is being stretched in the cross-machine direction (CD), if MD elasticity is desired. Table 2 shows the processing conditions of the stretching process and the properties of the fabrics produced.

In order to determine the relative wettability (and liquid holding capacity) of the cotton -surfaced laminates, a strike-through test using a simulated urine solution was performed on the samples. A Lenzing Lister Strike-Through-Time Instrument with an RS 232 PC Interface was utilized. The cotton-surfaced sides of the laminates were placed on the paper backup layers. For the laminates having only cotton surfaces, the patterned sides were placed on the paper layers. Whenever the SB side was tested, it was placed on the paper layers.

Results

1. The stretching process increased the basic weight of the fabrics. (Table 1 and 2).
2. The stretching process increased the fabric thickness.
3. Instantaneous elastic recovery at 50% extension and one-minute recovery time was in the range of 83-93% (Table 2).
4. Time dependent elastic recovery at 50% extension with three-minute constant loading time and one-minute recovery time, was in the range of 68-77%.

Although the strike-through times greatly exceed those of diaper cover stocks, for which the test was designed, it appeared that useful wettability data were obtained (Table 3 and Figure 5).

a. Sample #1 (SB1-TCPP1) had phenomenally high strike-through times as determined with the cotton surface against the backup paper, both before and after "Web Consolidation". Testing with the SB layer against the backup paper also resulted in very high strike-through times. This sample which had the lowest cotton content of 41% also appeared to have lowest tendency to lint compared to all of the other samples.

b. The two component laminate samples , #2, #3 and #4, resulted in increases in strike-through times as measured with the cotton side against the backup paper, after "Web Consolidation" of 4X to 10X, indicating that water absorbing properties of the stretchable laminates were greatly improved.

c. Strike-through times of TCPP/SB/TCPP laminates generally increased after "Web Consolidation", proportional to the increase in basis weight. However, it would be expected that greater strike-through time, even before " Web Consolidation", would result during the test due to the total increase in absorption capacity of laminates with cotton on both sides.

The results were very encouraging. Especially, since this was the first attempt at producing a cotton laminate with a spunbond, on-line. It is also the first time that these fabrics have been through the stretching process. There is ongoing work to determine the processing conditions that will yield optimum fabric performance. These fabrics would be suitable for medical isolation gowns, head covers, shoe covers, bed sheets, and pillowcases. They could also be used for consumer applications such as disposable underwear, towels, wipers and personal hygiene products.

Conclusions

Stretchable cotton containing nonwovens were produced having good elastic recovery. The composite base fabrics can be produced on-line by using standard spunbonding equipment. A post-treatment is used to create elasticity in the cross machine direction of the fabric. It appears that the computer interfacial " strike-through " test may be another useful tool in determining the effects of laminate fiber composition and of "Web Consolidation" on the wettability properties of the fabrics.

Cotton is an important component of these fabrics because of its soft hand, comfort, water holding capacity, moisture vapor transfer, wet strength, and consumer appeal. Finally, it appears that an inexpensive technology has been developed, which with additional refinement, could hasten the consumers' ready acceptance of nonwovens as highly desirable textile appeal.

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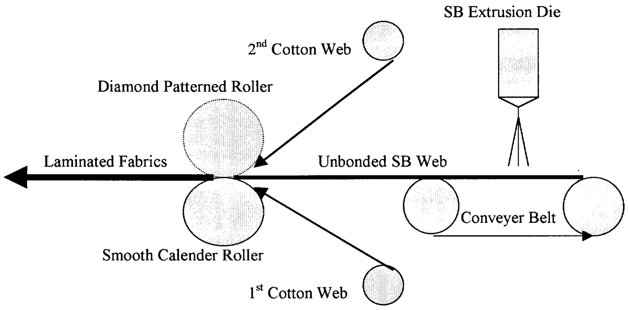


Figure 1 Lamination on the Spunbond line

Table 1. Sample Designation, Basisweight, and Thickness Results of the Laminates Produced on Spunbond Line

Samples #	Sample Designation *	Basis Weight			Thickness mm
		Layers oz./yd^2	Targeted oz./ yd^2	Actual oz./ yd^2 (g/m^2)	
1	SB1-TCPP1	1.0/0.7	1.7	1.64 (61)	0.572
2	SB2-TCPP1	0.5/0.7	1.2	1.26 (47)	0.509
3	TCPP1-SB2	0.7/0.5	1.2	1.50 (56)	0.497
4	SB2-TCPP2	0.5/0.6	1.1	1.05 (39)	0.361
5	SB2-TCPP3	0.5/1.5	2.0	1.88 (70)	0.536
6	TCPP1-SB1-TCPP1	1.7/1.0/0.7	2.4	2.45 (91)	0.804
7	TCPP1-SB2-TCPP1	0.7/0.5/0.7	1.9	1.91 (71)	0.753

Note:
SB1-1.0 oz./ yd^2 polypropylene (pp) spunbond webs
SB2-0.5 oz./ yd^2 PP webs
TCPP1-Thermally bonded 60/40 cotton/PP with 0.7 oz./yd^2 basis weight, 18% bond area and 36" width
TCPP2- Thermally bonded 60/40 cotton/PP with 0.6 oz./yd^2 basis weight, 40% bond area and 20" width
TCPP3- Thermally bonded 60/40 cotton/PP with 1.5 oz./yd^2 basis weight, 20% bond area and 20" width.

Table 2. Stretching Process Conditions and Fabric Properties After Processing.

Sample #	Sample [1] Top - Bottom	Stretch processing conditions		Weight		Thickness mm	Elastic Recovery in CD Direction at 50% extension (%)	
		Oven Tept.(F °)	Draw Ratio[2]	oz./yd^2	G/m^2		Instantaneous[3]	Time Dependent[4]
1	SB1-TCPP1	283	2.0	3.2	107	0.867	90	75
2	SB2-TCPP1	300	1.4	2.7	93	0.732	93	77
3	TCPP1-SB2	300	1.4	2.5	86	0.707	88	76
4	SB2-TCPP2	296	1.3	2.3	78	0.515	91	73
6A	TCPP1-SB1-TCPP1	306	1.4	4.7	161	1.023	89	73
6B		300	1.4	4.3	146	1.039	85	70
6C		295	1.4	4.0	137	1.025	84	68
7A	TCPP1-SB2-TCPP1	295	1.6	3.7	125	1.056	85	68
7B		300	1.6	3.7	125	1.060	83	70

Note:
1. Sample designation, see Table 1
2. Draw Ratio = wind speed/ unwind speed
3. Instantaneous extension and release and one minute recovery time
4. Instantaneous extension, three minutes constant loading and one minute recovery time.

Figure 2. Cross-Sectional SEM photograph of Laminate, Sample #1 (SB1-TCPP1)

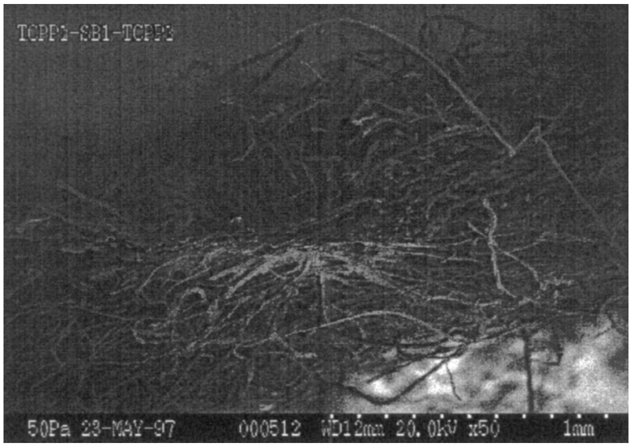


Figure 3. Cross-Sectional SEM photograph of Laminate, Sample #6 (TCPP1-SB1-TCPP1)

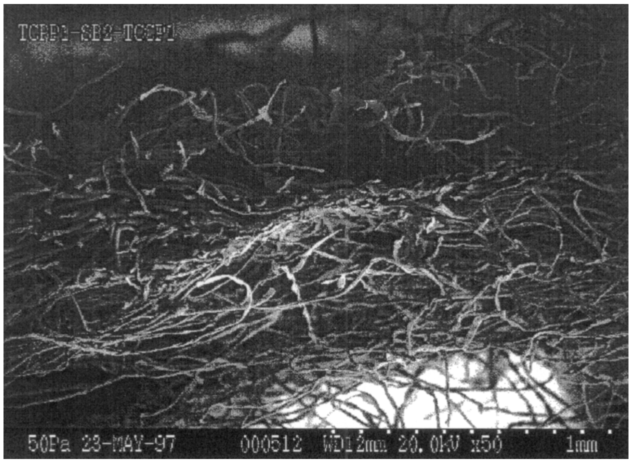
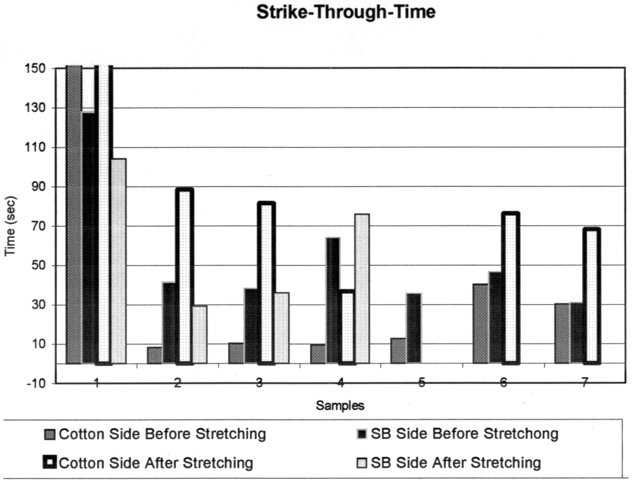


Figure 4. Cross-Sectional SEM photograph of Laminate, Sample #7 (TCPP1-SB2-TCPP1)



#1: SB1-TCPP1 #2: SB2-TCPP1 #3: TCPP2-SB2 #4: SB2-TCPP2
#5: SB2-TCPP3 #6: TCPP1-SB1-TCPP1 #7: TCPP1-SB2-TCPP1

Figure 5. Strike-Through-Times of Laminates