COTTON/POLYESTER NONWOVEN BLEND WITH ANTIBACTERIAL ACTIVITY

T. L. Vigo, D. V. Parikh and G. F. Danna
USDA, ARS, SRRC
New Orleans, LA

Abstract

Antibacterial needlepunched cotton/polyester webs of varying fiber content (10/90, 20/80 and 30/70 cotton/polyester) were produced by spraying a dilute aqueous dispersion of an environmentally benign antibacterial agent (magnesium hydroperoxyacetate or MHPA), drying and curing the webs, then needlepunching the webs. The composition of the antibacterial agent was characterized by differential scanning calorimetry, and by its peroxide content and that of the modified nonwovens as determined by iodometric titration. Untreated and modified needlepunched nonwovens had comparable physical properties such as bursting strength and stiffness, but the treated nonwovens also had outstanding antibacterial activity at peroxide contents as low as 0.22 %. Applications for the treated blended nonwovens are numerous and include air filters, wall coverings, automotive interiors and interlinings.

Introduction

Cotton and other types of fibers (natural, synthetic and fiber blends) have been treated with aqueous dispersions of new environmentally benign antibacterial agents (magnesium hydroperoxyacetate--MHPA and magnesium dihydroperoxide--MDHP), then cured to bind these agents to the fiber surface (Vigo and Danna, 1996). Previous studies demonstrated that the unique geometry and surface area of the cotton fiber resulted in greater durability of the agent on cotton and cotton blend fabrics than all synthetic, mercerized cotton and rayon fabrics (Vigo, Danna and Goynes, 1999). It was also determined that agents could be incorporated into fabricated nonwovens of varying fiber type to produce antibacterial activity (Vigo, Danna and Parikh, 1999). However, there were no studies that evaluated the incorporation of these magnesium-peroxide-based antibacterial agents into nonwovens at earlier stages of formation (such as binding at the web stage prior to conversion into a nonwoven fabric) for treated cotton webs blended with other fibers or alternatively treatment of a cotton/synthetic fiber blend prior to formation of nonwoven fabrics. The latter topic is described in this study.

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Materials and Methods

The fibers used in this study were bleached cotton fibers obtained from Veratec, Inc. which were characterized by HVI instrumentation for ten replications with an average micronaire value of 5.38 (standard deviation 0.03) and an average staple length of 0.89 in. (standard deviation 0.015). Staple polyester fibers Trevira P121 obtained from Hoechst-Celanese had an average staple length of 1.33 in. (five replications, standard deviation 0.01).

Potassium iodide, hydrogen peroxide (30%), hydrochloric acid (37%), standardized 0.1N sodium thiosulfate (J. T. Baker, Inc.) and magnesium acetate tetrahydrate (Fluka) were all reagent grade.

The MHPA was prepared as previously described (Vigo and Danna, 1996) by carefully heating (at or below 90ºC) 30% aq. hydrogen peroxide and solid magnesium acetate tetrahydrate (mole ratio of 29: 1) in a microprocessor-controlled force-draft oven with a modified exhaust system to vent unreacted or accumulated H_2O_2/acetic acid vapors. Cotton and staple polyester fibers were opened separately on a Spinlab 338 fiber opener and blender. After the cotton fibers were carded, they were placed in a plastic bag containing a 15% aq. dispersion of the freshly prepared MHPA, immersed and padded at 40 psi four times to a wet pickup of 140%, dried/cured for 1.75 hr at 200ºC in a force-draft oven to give a dried and conditioned web with 2.24% active oxygen. When 10 g of the modified cotton web was opened and blended with 23 g of untreated polyester fibers, it was not possible to obtain a useful carded, blended web because the treated fibers adhered to parts of the carding machine. The procedure was modified to produce blended, untreated carded webs of 10/90, 20/80 and 30/70 cotton/polyester content by spraying each of the webs with a 4% aq. dispersion of the MHPA, passing the webs through squeeze rolls to a wet pickup of 140%, air-drying for 2 hr, then oven-drying for 30 min at 100ºC. Each of the modified and carded webs were then needlepunched once on each side (12 mm needling depth, 18.1 needles per cm width, 23 penetrations per cm^2 with two passages through a Morrison Berkshire needleloom equipped with a single 31.8 cm board containing 575 needles). The antibacterial treatment did not cause any difficulty in the needlepunching process, i. e., the needles did no break. All needlepunched nonwovens had a wt. of $65g/m^2$ + /- 5.

Peroxide (active oxygen) contents of the MHPA and modified nonwovens were determined by iodometric titration. Melting points and thermal behavior of $Mg(OAc)_2.4H_2O$ and the MHPA were determined by differential scanning calorimetry; both procedures are described in a previous publication (Vigo and Danna, 1996). Physical tests for untreated and treated nonwoven blend fabrics were conducted by standard test methods (stiffness, Federal Laboratory Test Method 5202; air permeability, ASTM Method 737-96; bursting strength, Method D3786-87) at our laboratory. The antibacterial activity of untreated and treated nonwovens were determined by AATCC Method 100 by NAMSA Labs, Marietta, Ga.

Results and Discussion

Attempts to treat cotton fibers with 15% aq. dispersions of MHPA prior to carding and blending with untreated polyester fibers were not successful. It was impractical and tedious to uniformly wet the cotton fibers in a plastic bag and very long drying/curing times (over 2 hr. at 200ºC) were required. Moreover, the treated and dried cotton could not be blended with untreated polyester because the resinous nature of the treated cotton fibers caused them to adhere to metal parts of the carding machine.

In contrast, when the carded cotton/polyester webs were treated with much more dilute aq. dispersions (4%) of MHPA by spraying from an atomized bottle, curing occurred much quicker (30 min) at a lower temperature (100ºC). The resultant webs were then needle punched to produce three different blend levels of cotton/polyester nonwovens (10/90, 20/80 and 30/70 that respectively had active oxygen contents of 0.22, 0.33 and 0.81%). The greater levels with greater amounts of cotton in the blend are consistent with results obtained with woven fabrics in an earlier study (Vigo, Danna and Goynes, 1999).

Physical properties of the treated, blended nonwovens were comparable to those of corresponding untreated control blend nonwovens. Air permeability of all untreated cotton/polyester blend fabrics was too high to measure; however, all treated blend fabrics had air permeability values at the upper end of the instrument range (603 to 747). Stiffness (expressed as bending moment) was comparable for 10/90 untreated and treated cotton/polyester fabrics (230 and 242, respectively), greater for the treated 20/80 blend (400) compared to the untreated 20/80 blend (180), but lower for the treated 30/70 blend (158) compared to the untreated 30/70 blend (420). Bursting strength in absolute terms was greatest for the 20/80 cotton/polyester blends (35 for untreated, 33 for treated), lower for the 10/90 blends (22 for untreated, 26 for treated), and lowest for the 30/70 blends (21 for untreated, 19 for treated).

The antibacterial activity of the treated cotton/polyester blends against representative gram-positive (*S. aureus*) and gram-negative (*K.. pneumoniae)* bacteria were excellent (>99.5%) at all levels of active oxygen or peroxide content (Table 1), while the corresponding untreated control blends gave no reduction in microbial growth.

Since needlepunched nonwovens account for 10% of all nonwovens produced, the modified nonwoven blends may be used for numerous applications. Important applications are envisioned for filtration in food and pharmaceutical processing and in air-conditioning filters to remove undesirable microbes. These antibacterial nonwovens could also be used in hygenic materials, bedding, insulation, disposable blankets, automotive components, home furnishings, apparel interlinings and other applications where bacterial control is required or useful.

Summary

Treatment of blended and carded webs of varying cotton/polyester content (10/90, 20/80 and 30/70) with dilute aq. dispersions of MHPA produced nonwoven fabrics with excellent antibacterial activity against representative gram-positive and gram-negative bacteria. The treated fabrics had comparable physical properties (air permeability, stiffness and bursting strength) to untreated fabrics. Improvements in treatment are envisioned by use of foam finishing and/or use of commercial spray systems.

References

Vigo, T. L. and Danna, G. F. Magnesium hydroperoxyacetate (MHPA) and magnesium dihydroperoxide (MDHP): new antibacterial agents for fibrous substrates. Polymers for Advanced Technologies 7(1):17-26.

Vigo, T. L., Danna, G. F. and Goynes, W. R. Affinity and durability of magnesium peroxide-based antibacterial agents to cellulosic substrates.
1999. Textile Chemist and Colorist 31(1): 29-33.

Vigo, T. L., Danna, G. F. and Parikh, D. V. Antimicrobial cellulosic nonwovens. 1999. Proceedings Beltwide Cotton Conference, Vol. 2: 1344-1345.

Table 1. Antibacterial activity of needlepunched cotton/polyester nonwovens.

Cotton/polyester	% Active O_2	Antibacterial Activity[a]	
		g^+	g^-
10/90	None[b]	NR	NR
10/90	0.22	99.94	99.94
20/80	None[b]	NR	NR
20/80	0.33	99.94	99.50
30/70	None[b]	NR	NR
30/70	0.81	99.86	99.94

[a] g^+ = *S. aureus* and g^- =*K. pneumoniae*. Values are % reduction bacterial growth--AATCC Method 100; NR= no reduction in bacterial growth.
[b] Corresponding untreated control fabrics.