ANTIMICROBIAL CELLULOSIC NONWOVENS

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

Abstract

New environmentally benign antibacterial agents [magnesium hydroperoxy-acetate(MHPA) and magnesium dihydroperoxide (MDHP)--reaction products of $Mg(OAc)_2.4H_2O$ and H_2O_2] were affixed to a variety of cellulosic nonwoven fabrics (commercial laboratory paper towels reinforced with nylon mesh--72g/m^2; 50/50 cotton/polyester hydroentangled gauze--40 g/m^2; bleached staple cotton, needle-punched— 160 g/m^2; bleached and mercerized staple cotton, needle-punched—160 g/m^2) by conventional pad-cure methods. The bound antibacterial agents were evaluated for their affinity and durability to leaching for each nonwoven fabric. Elemental analyses for magnesium and bound active peroxide were used for the characterization.

Introduction

Attachment of new antibacterial agents (MHPA and MDHP)to cotton and other types of fibers have been described in a recently issued patent and publication (Vigo and Danna, 1996;1997). Cotton and cotton blends retained much greater amounts of the agents after laundering than did fabrics made of synthetic fibers. It was also determined later (Vigo, et al., 1998) that woven cotton and cotton blend fabrics retain greater amounts of bound antibacterial agents MHPA/MDHP after laundering than other woven cellulosic fabrics (e.g., mercerized cotton and viscose rayon). Surface area and geometry of the cotton fiber are conducive to this retention. However, little data is available on the affinity and durability of these agents to nonwoven substrates. Thus, a comparative study of the affinity of the agents to various cellulosic-containing nonwoven fabrics and the durability of the agents to leaching was conducted.

Materials and Methods

The following nonwoven fabrics and materials were used in the study: commercial laboratory paper towels reinforced with nylon mesh--72g/m^2; 50/50 cotton/polyester hydroentangled gauze--40 g/m^2 (obtained from Johnson & Johnson); bleached staple cotton, needle-punched— 160 g/m^2; bleached and mercerized staple cotton, needle-punched—160 g/m^2 (latter two fabrics made in our SRRC laboratories; Parikh, et al.,1999).

Potassium iodide, hydrogen peroxide (30%), hydrochloric acid (37%), standardized 0.1N sodium thiosulfate, sodium hydroxide (J. T. Baker, Inc.) and magnesium acetate tetrahydrate (Fluka) were all reagent-grade. Antibacterial reaction products were prepared as previously described by heating 16:1 mole ratios of 30% aq.H_2O_2 and $Mg(OAc)_2.4H_2O$ at or below 90^{o}C (caution-temperature must be kept below this level to minimize a buildup of potentially explosive unreacted H_2O_2; also, exposure to metal contaminants that react violently with H_2O_2 must be avoided)to give compositions with active peroxide contents of 12%. Each nonwoven substrate was immersed in a 16% aq. dispersion of MHPA/MDHP (derived from 16:1 mole ratios of reactants described above containing 12% active peroxide) to give wet pickups (pressure of 40 psi)respectively of 98% (paper towel), 119% and 125% (bleached, needle-punched and bleached/mercerized, needle-punched) and 277% (double treatment, pad-cure; pad-cure for the gauze for comparable add-on). Fabrics were then cured 3 min/125^{o}C, tap water-rinsed 10 min/50^{o}C to remove excess, unbound antibacterial agents, then dried 10 min/125^{o}C, except for the gauze which was dried 5 min/125^{o}C. Leaching was conducted by placing treated fabrics in 2 gallons of warm tap water (40^{o}C) for 1 hr. (with intermittent agitation every 10 min for a duration of 5 seconds), and repeating this process for an additional hour, followed by blotting the samples on paper towels, then drying them under the same conditions described above after their cure. Magnesium content of the fabrics was determined by commercial analysis. Peroxide content of fabrics was determined by iodometric titration as previously described.

Results and Discussion

A comparative study was made of the affinity (initial amount of peroxide bound and not leached)and durability (amount of peroxide remaining after leaching for two 1 hour intervals) of various cellulosic and cellulosic blend nonwoven substrates. Nonwovens used in the study also represented diverse methods for their preparation: needle-punched, air-laid (paper towel) and hydroentangled (gauze). Because of the gauze's openness, it was necessary to give it a double treatment to obtain % bound agent comparable to other nonwoven substrates. Affinity of the MHPA/MDHP for various fibrous nonwoven substrates was about the same (bound peroxide in the range of 0.63% for bleached/mercerized, needle-punched cotton to 0.76% for the bleached, needle-punched cotton--Table I). Comparable % Mg values were also observed (range of 5250 ppm for bleached/mercerized, needle-punched cotton to 6800 ppm for the bleached, needle-punched cotton). Irrespective of diverse differences in fiber type, the amount of antibacterial agent before and after leaching was comparable to that obtained for five laundering cycles with woven fabrics containing the agent. Bound peroxide after leaching was 56-67% that of unleached nonwoven materials. Similar amounts of magnesium were retained after leaching (56-67%), except for the bleached cotton, needle-punched fabric which only retained 53% compared

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1344-1345 (1999)
National Cotton Council, Memphis TN

to retention of 62% peroxide after leaching. The amount of bound antibacterial agent retained after leaching, as determined by peroxide content, far exceeds the minimum amount of bound peroxide (as low as 0.10% for woven substrates) required to impart antibacterial activity, and thus may offer the opportunity to economically apply far less agent for disposable nonwovens. Presumably, openness of the nonwoven structure (irrespective of fiber surface characteristics) is the controlling factor in the affinity and durability of these antibacterial agents. Scanning electron microscopy is in progress to verify this hypothesis.

Table 1. Affinity and durability of MHPA/MDHP antibacterial agents to various fibrous nonwoven substrates.

Fibrous Substrate	Before Leaching		After Leaching	
	% Peroxide	% Mg(ppm)[a]	% Peroxide	% Mg(ppm)
Bleached cotton needle-punched	0.76	6800	0.47	3570
Bleached/ mercerzed cotton, needle-punched	0.63	5250	0.40	3510
Nylon-reinforced paper towel	0.66	6130	0.44	4050
50/50 Cotton/ polyester gauze	0.74	6360	0.41	3740

[a] %Mg for untreated nonwovens ranged from 80-125 ppm.

Conclusions

A diverse group of cellulosic and cellulosic blend nonwoven fibrous substrates had the same affinity for MHPA/MDHP antibacterial agents applied by a pad-cure method. These fabrics and materials also retained comparable amounts of the agent (determined by magnesium and active oxygen analyses) after leaching. The openness of the nonwoven structures appear to be the determining factor for affinity and durability in contrast to fiber surface area in earlier studies with woven fabrics.

References

Parikh, D. V., T. A. Calamari, W. R. Goynes, J. P. Moreau and N. Sachinvala. 1999. Absorption characteristics of mercerized and chemically modified cotton fiber nonwoven composites. For presentation at EDENA Index 99 Congress, April, 1999.

Vigo, T. L. and G. F. Danna. 1996. Magnesium hydroperoxyacetate (MHPA) and magnesium dihydroperoxide (MDHP): new antibacterial agents for fibrous substrates. Polymers for Advanced Technologies 7(1):17-26.

Vigo, T. L. and G. F. Danna. Aug. 12, 1997. Reaction products of magnesium acetate and hydrogen peroxide for imparting antibacterial activity to fibrous substrates. U. S. Patent 5,656,037.

Vigo, T. L., G. F. Danna and W. R. Goynes. 1998. Affinity of new environmentally benign antibacterial agents to cotton and cotton blends. Proceedings Beltwide Cotton Conferences. 748-749.