AFFINITY OF NEW ENVIRONMENTALLY BENIGN ANTIBACTERIAL AGENTS TO COTTON AND COTTON BLENDS

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Abstract

Magnesium hydroperoxyacetate (MHPA) and magnesium dihydroperoxide (MDHP)--reaction products of $Mg(OAc)_2.4H_2O$ and H_2O_2--were affixed to cellulosic fabrics (cotton, mercerized cotton, viscose rayon) and cotton blends (three cotton/polyester and one cotton/wool) by conventional pad-cure methods. The bound antibacterial agents were evaluated for their affinity and durability to laundering for each fabric. Elemental analyses for magnesium and bound active peroxide and scanning electron microscopy were used for characterization. Cotton retained the most bound agent after laundering, followed by cotton blends, then mercerized cotton and viscose rayon. Surface area, convolutions in cotton, porosity and capillarity favor cotton compared to rayon and mercerized cotton with regard to retention of these antibacterial agents.

Introduction

Application of new antibacterial agents (MHPA and MDHP)to cotton and other types of fibers has been recently described (1,2)and offers several advantages over a previous *in situ* application using zinc acetate and hydrogen peroxide(3). Although cotton fabrics had much better affinity and durability than cotton/polyester blends or prototype synthetic fibers (e.g., polyamide and polypropylene), more detailed studies were needed to determine structural fiber characteristics that favored affinity and durability for cotton.

Materials and Methods

The following fabrics were used in the study: 100% cotton printcloth (98 g/m^2), 60/40 cotton/polyester core wrapped (cotton wrapped/polyester core(300 g/m^2), 50/50 cotton/polyester sheeting (91 g/m^2), 35/65 cotton/polyester sheeting (78 g/m^2),38/62 union cloth (cotton combed filling/wool worsted warp(150 g/m^2), viscose rayon (126 g/m^2), and 100% cotton printcloth mercerized in 23% NaOH for 30 min, neutralized with dilute acetic acid and dried (129 g/m^2).

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 14:1 and 28:1 mole ratios of 30% aq.H_2O_2 and $Mg(OAc)_2.4H_2O$ as previously described (1) at or below 90°C (caution-temperature must be kept below this level to minimize buildup of potentially explosive unreacted H_2O_2; also, must avoid exposure to metal contaminants that react violently with H_2O_2)to give compositions with active peroxide contents respectively of 12% and 24%. For a single application, each fabric was immersed in 25% aq. dispersion of MHPA (derived from 14:1 mole ratio of reactants containing 12% active peroxide) to give wet pickups of 104% and 74% respectively for cotton and 38/62 cotton/wool. Fabrics were then cured 5 min/100°C, tap water-rinsed 5 min/50°C and dried 5 min/100°C. For a dual application, fabrics were immersed in 15% aq. dispersions of MHPA (derived from 28:1 mole ratio of reactants containing 24% active peroxide) to obtain wet pickups for first and second treatments of 98/96,89/89, 77/88, 68/71, 83/87 and 99/101 respectively for cotton,60/40 cotton/polyester core wrapped, 50/50 cotton/polyester, 35/65 cotton/polyester, mercerized cotton and viscose rayon fabrics. After the initial immersion and removal of excess solutions, fabrics were cured 3 min/100°C, rinsed 1 min/50°C, dried 3 min/100°C. Fabrics were immersed again, excess solution removed, then cured 3 min/100°C, rinsed 10 min/50°C, dried 3 min/100°C.

Magnesium content of the fabrics was determined by commercial analysis. Peroxide content of fabrics was determined by iodometric titration as previously described (1). Thermal behavior of the 14:1 and 28:1 reaction products was determined by differential scanning calorimetry as previously described (1). Scanning electron microscopy (SEM) was conducted by attaching 0.5-in. cut samples to stubs previously coated with a nonwicking adhesive. Samples were sputter-coated to prevent charging in the electron beam, and studied at 0 and 45° to observe both fabric surfaces and cut yarn ends.

Results and Discussion

A comparative study was made of the affinity (initial amount of peroxide bound at 0 launderings) and durability (amount of peroxide remaining after 10 launderings) of various cotton, cotton blend and other cellulosic-type fabrics (rayon and mercerized cotton). Most of the data presented here (Table I) are for fabrics given dual applications. Although magnesium contents are not shown, they were generally consistent with the amount of bound peroxide before and after laundering.

The initial affinity of the magnesium-peroxide antibacterial agents to the various types of fabrics is governed by the geometry of the fiber surface and to some extent the construction of the yarns in the fabrics. As noted in SEM photomicrographs of unlaundered, treated fabrics

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(correlating with observed peroxide contents), cotton and viscose rayon fabrics had more agent bound than mercerized cotton and 50/50 and 35/65 cotton/polyester blend fabrics of comparable weight. The highest amount of peroxide bound however was observed in the heavier weight core-wrapped 60/40 cotton/polyester blend (2.11%). SEM photomicrographs indicate that the core polyester bundle of fibers is completely filled with the agent which is also deposited on the cotton fibers in folds and between fibers. The good affinity of the agent for the cotton/wool blend relative to the cotton fabric is probably due to thicker yarns and equal distribution of the agent on both cotton and wool fibers.

Retention of the antibacterial agents after 10 launderings (Table 1) exhibits a different profile for the various fabrics relative to their original affinity for these agents. Although the mercerized cotton and viscose rayon fabrics contain comparable amounts of the agent to all cotton and greater amounts than the two cotton/polyester blends (50/50 and 35/65) before laundering, the amount of agent retained on these two fabrics after laundering is far less (9% and 5%, respectively) than cotton or the two cotton blends (26-30%). SEM shows that after laundering the agents are retained in the folds and between fibers in cotton and the cotton portion of the blends. Conversely, the polyester fibers and the cellulosic fibers with smooth surfaces (rayon and mercerized cotton) retain very little of the agent after laundering.

In the heavier fabrics (core-wrapped 60/40 cotton/polyester and 38/62 cotton/wool), the cotton component exhibits a similar behavior as in other cotton or cotton blend fabrics after laundering. However, the wool component of the cotton/wool blend retains more agent than a comparable polyester component. In the core-wrapped fabric, the protection of the core polyester component by the cotton wrap appears to cause higher initial retention of agent in the polyester core than in conventional polyester fibers of cotton/ polyester blends.

Conclusions

Cotton and cotton blend fabrics retain greater amounts of bound antibacterial agents MHPA/MDHP after laundering than do other cellulosic fabrics (e.g., mercerized cotton and viscose rayon). This was verified by correlation of magnesium and active peroxide contents with scanning electron microscopy. The surface area and geometry of the cotton fiber are conducive to this retention. However, other factors such as yarn thickness and fabric construction may also favor better retention of these agents. Cotton and to some extent wool fibers have a higher affinity and retention for the agent due to their unique surface characteristics. Further studies are in progress to evaluate cotton, cotton/wool and cotton/polyester blends to optimize and more fully characterize retention of these new and environmentally benign antibacterial agents.

References

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Table 1. Application of MHPA/MDHP products to cotton, cotton blends and other cellulosic fabrics[a].

Fiber type	% Wt.Gain	% Peroxide	% Peroxide Retained	Laundering Cycles
100% Cotton	7.2	1.84	100	0
	---	0.48	26	10
60/40 C/PET	8.0	2.11	100	0
Core wrapped	---	0.53	25	10
50/50 C/PET	4.6	1.25	100	0
	---	0.32	26	10
35/65 C/PET	3.2	0.90	100	0
	---	0.27	30	10
100% Mercerized	4.0	1.30	100	0
cotton	---	0.12	9	10
100% Viscose	7.4	1.77	100	0
rayon	---	0.08	5	10
100% Cotton	1.8	0.75	100	0
	---	0.26	35	10
38/62 Cotton/	5.0	0.88	100	0
wool worsted	---	0.20	23	10

[a] First six sets of fabrics were given dual applications; last two sets were given single applications; C/PET = cotton/polyester.