

Multifunctional Cotton Fabric: Antimicrobial and Durable Press

Idris Cerkez,¹ Hasan B. Kocer,^{1,2} S. D. Worley,² R. M. Broughton,¹ T. S. Huang³

¹Department of Polymer and Fiber Engineering, Auburn University, Auburn, Alabama 36849

²Department of Chemistry and Biochemistry, Auburn University, Auburn, Alabama 36849

³Department of Poultry Science, Auburn University, Auburn, Alabama 36849

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ABSTRACT: 2-Amino-2-methyl-1-propanol (AMP) was coated onto cotton fabric with 1,2,3,4-butanetetracarboxylic acid (BTCA) as a crosslinking agent to simultaneously impart antimicrobial and durable-press functionalities. The coatings were characterized and confirmed by attenuated total reflectance-IR and thermogravimetric analysis. The coated fabrics were rendered biocidal upon exposure to dilute household bleach, and the chlorinated swatches exhibited about 6 log reductions of *Escherichia coli* O157:H7 and *Staphylococcus aureus* within 5 min of contact time. A concentration of 1.5 wt % AMP was sufficient to produce

this biocidal efficacy. Increasing the BTCA content of the coating improved the wrinkle recovery angle. The coatings were very stable toward repeated laundering, and they exhibited sufficient halogen storage stabilities for industrial applications. A photolytic decomposition was observed when the coatings were exposed to UVA light. © 2011 Wiley Periodicals, Inc. *J Appl Polym Sci* 124: 4230–4238, 2012

Key words: coatings; crosslinking; fibers; functionalization of polymers

INTRODUCTION

Health-care-associated infection is one of the world's most devastating problems, causing millions of deaths and billions of dollars in health care each year. The annual direct hospital cost of treating health-care-associated infections in the United States is estimated to be in the range \$28.4–33.6 billion.¹ In 2002, 1.7 million people in the United States were infected by health-care-associated infections; this led to around 99,000 deaths.² Textile materials, particularly natural fibers, are very susceptible to microbial growth. Therefore, the antimicrobial treatment of medical textiles, such as gowns, bed sheets, uniforms, aprons, and masks, is essential to reduce the risk of spreading pathogenic microorganisms.

Numerous biocidal materials, including quaternary ammonium salts,^{3–6} *N*-halamines,^{7–12} metal ions,^{13,14} biguanides,^{15,16} and phosphonium compounds,^{17,18} have been studied as a means of preventing the transmission of microbial infections. Among those, *N*-halamines are one of the most

effective classes of biocidal compounds applied to inactivate a broad spectrum of microorganisms, including Gram-negative and Gram-positive bacteria, fungi, viruses, and yeasts in relatively brief contact times.¹² The inactivation mechanism involves the transfer of the oxidative halogen to the microbial cell membrane.¹⁹ Once all of the halogen on the surface is consumed, it can be regenerated simply by exposure to a halogen source, such as household bleach (Fig. 1). Three decades of *N*-halamine work in these laboratories began with water disinfection in the 1980s.¹² Later, polymeric *N*-halamines were introduced to aqueous media disinfection.^{20,21} Then, the work was extended to the antimicrobial treatment of materials such as cellulose,^{10,22,23} nylon,²⁴ polyester,²⁵ polyurethane,^{26,27} and polyacrylonitrile.²⁸ Extensive work has been done on antimicrobial coatings of cellulose because it is widely used in the medical textile industry. Various *N*-halamine compounds have been immobilized onto cotton fabric through tethering groups,^{29,30} grafting,^{31,32} or electrostatic attraction.³³

Poly(carboxylic acid) derivatives have been widely investigated as durable-press finishing agents because they do not release formaldehyde as conventional dimethyloldihydroxyethylene urea does.³⁴ Several studies pertaining to the poly(carboxylic acid) treatment of cotton fabric have been done as a means of optimizing durable-press finishing and to minimize the mechanical loss of cotton fabric caused by the treatment process.^{35–38}

Additional Supporting Information may be found in the online version of this article.

Correspondence to: S. D. Worley (worlesd@auburn.edu).

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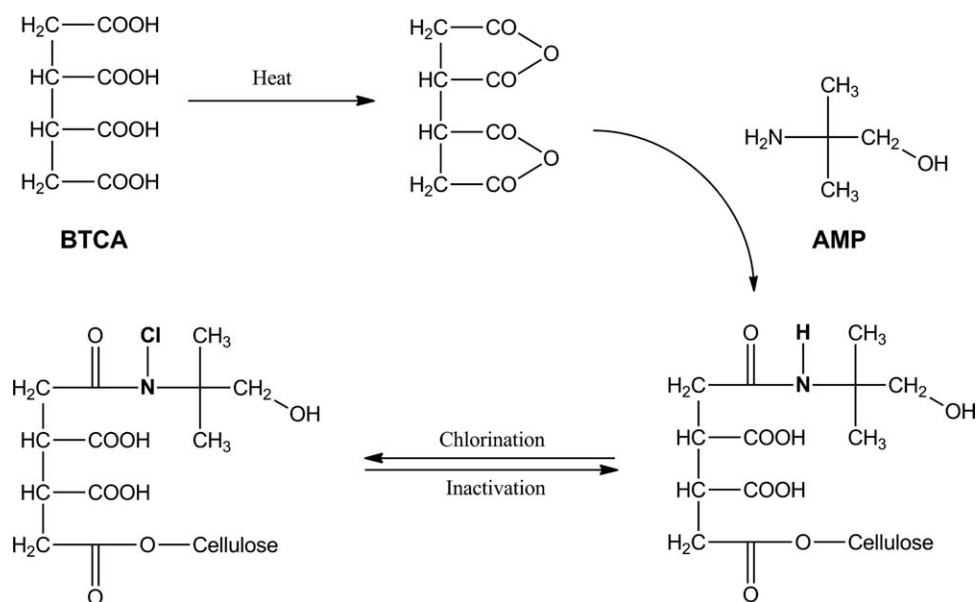


Figure 1 Attachment of AMP to cellulose and conversion to an *N*-halamine.

There is a need to make multifunctional coatings on textile surfaces to provide health safety and improved quality of life. In this study, we aimed to impart biocidal and durable-press functionalities to cotton fabric by a simple pad-dry-cure procedure. It was reported earlier that cyclic *N*-halamines could be coated onto cotton with durable-press finishing treatments with poly(carboxylic acids).^{39,40} In this study, an acyclic *N*-halamine precursor, 2-amino-2-methyl-1-propanol (AMP), was applied onto cotton fabric with 1,2,3,4-butanetetracarboxylic acid (BTCA) as a crosslinking agent with the purpose of providing an inexpensive way of establishing antimicrobial and durable-press functionalities. The coating was rendered biocidal upon dilute household bleach treatment and was used to inactivate Gram-negative and Gram-positive bacteria. Wrinkle recovery angle (WRA) measurements were performed to evaluate the durable-press efficacy. In addition, mechanical testing, washing stabilities, and UVA and storage stability evaluations were conducted.

EXPERIMENTAL

Materials

All starting chemicals and solvents were purchased from Aldrich Chemical Co. (Milwaukee, WI) or TCI America (Boston, MA) and were used as is unless otherwise noted. Desized, scoured, and bleached (100%) cotton (style 400 cotton print cloth) was obtained from Testfabrics, Inc. (West Pittston, PA). Clorox brand household bleach (Clorox, Inc., Oakland, CA) was used for chlorination. Bacterial cultures of *Staphylococcus aureus* (ATCC 6538) and *Escherichia coli* (O157:H7 ATCC 43895) were

purchased from American Type Culture Collection (Rockville, MD), and Trypticase soy agar was obtained from Difco Laboratories (Detroit, MI).

Instrumentation

¹³C-NMR spectra, recorded with 1024 scans, were obtained with a Bruker 400-MHz spectrometer (Madison, WI). Attenuated total reflectance (ATR)-IR data, recorded with 64 scans at a 4-cm⁻¹ resolution, were obtained with a Nicolet 6700 Fourier transform infrared spectrometer (West Palm Beach, FL) with an ATR accessory on a diamond crystal. An Instron model 1122 textile tester (Norwood, MA) was used for mechanical testing. A TA Instruments Q500 (New Castle, DE) was used to obtain the thermogravimetric analysis (TGA) data, which were collected at a heating rate of 10°C/min under a nitrogen atmosphere.

Coating and chlorination procedure

BTCA and AMP were dissolved in water at specified concentrations. Cotton swatches were soaked in the coating solution for 15 min and then uniformly padded through a laboratory wringer (Birch Brothers Southern, Waxhaw, NC). The immersed swatches were dried at 130°C for 10 min; this was followed by curing at 175°C for 5 min. Finally, the swatches were washed vigorously with 0.5 wt % detergent water for 15 min and then rinsed with distilled water.

The coated sample swatches were chlorinated with a 10 wt % aqueous solution of household bleach (0.6 wt % Cl⁺) at pH 7 for 1 h; this was followed by rinsing with distilled water. The cotton swatches were dried at 45°C for 1 h to remove any

occluded free chlorine from the surfaces. An iodometric/thiosulfate titration³⁰ was used to determine oxidative the percentage of Cl^+ content on the swatches. The weight percentage of chlorine was calculated according to Eq. (1):

$$\text{Cl}^+(\%) = \left(\frac{35.45NV}{2W} \right) \times 100 \quad (1)$$

In this equation, Cl^+ (%) is the weight percentage of oxidative chlorine on the samples, N and V are the normality (equiv/L) and volume (L) of the $\text{Na}_2\text{S}_2\text{O}_3$ (titrant), respectively, and W is the weight of the cotton sample (g).

Synthesis of 2,3-bis[2-[(1-hydroxyl-2-methylpropan-2-yl)amino]-2-oxoethyl]succinic acid

In a round-bottom flask, 20 mmol of AMP and 10 mmol of BTCA were dissolved in 25 mL of anhydrous N,N -dimethylacetamide. The temperature was gradually increased to 155°C within 15 min, and the solution was stirred at that temperature for 5 min. Then, the solution was cooled to room temperature, and 50 mL of chloroform was added. A white, solid product precipitated and was recovered by filtration.

¹³C-NMR (D_2O , 400 MHz, δ): 23.98, 38.77, 47.94, 57.41, 68.87, 180.42, 181.66.

Stability testing

AATCC test method 61–1996 and a laboratory model Launder-Ometer (Irving, TX) were used to evaluate the durability of the coatings and the stability of chlorine on the swatches toward laundering. To evaluate the stability of bound chlorine toward washing, one set of the samples was chlorinated before washing. To address the durability of the unchlorinated and chlorinated coatings as a function of washing cycles, a second set of samples was chlorinated both before and after the washing cycles, and a third set was chlorinated only after the washing cycles, respectively.

An accelerated weathering tester (The Q-Panel Co., Cleveland, OH) was used to evaluate the UVA light stability of the bound chlorine and the coatings on the cotton fabric. Chlorinated and unchlorinated cotton swatches were exposed to UVA light (type A, 315–400 nm) for times in the range 1–72 h. One set of the chlorinated samples was titrated after a specified time of UVA exposure to assess the chlorine stability, and the other set was rechlorinated and then titrated to address rechargeability. The unchlorinated samples were chlorinated and then titrated to evaluate the durability of the coating itself.

WRA measurement and mechanical testing

WRA measurements were performed with AATCC test method 66-1998, option 2. With this method,

$40 \times 15 \text{ mm}^2$ swatches were folded, and $500 \pm 5 \text{ g}$ of weight was applied onto the swatches for 5 min, after which time, the weight was removed. The recovery angles were measured in both *warp* (lengthwise yarns, c) and *weft* (widthwise yarns, f) directions, and the sum of these angles was reported as the WRA.

ASTM D 5035-95 and ASTM D 2261-96 were employed for tensile and tear strength determinations, respectively. All of the samples were conditioned under standard laboratory conditions (65% relative humidity and 21°C) for 1 day before testing. A crosshead speed of 12 in./min was applied to the swatches, and four replicates were produced for each sample, with their averages reported herein.

Biocidal efficacy testing

A modified AATCC sandwich test was conducted to evaluate the biocidal efficacies of the coatings. In this method, chlorinated and unchlorinated (control sample) swatches were challenged with *S. aureus* (ATCC 6538) and *E. coli* O157:H7 (ATCC 43895). Suspensions of known bacterial populations [colony-forming units (CFU)] were prepared by suspension of the bacteria in pH 7 phosphate buffer solution (100 μM). Then, 25 μL of this suspension was placed in the center of a 2.54-cm square swatch, and a second identical swatch was placed on top of it. To ensure adequate contact with the bacteria, a sterile weight was placed on the sandwich. Three different contact times were employed: 5, 10, and 30 min. After the specified contact times, the samples were quenched with a 0.02N sodium thiosulfate solution by vortexing for 2 min to neutralize any oxidative chlorine left on the sample. Serial dilutions were made with pH 7, 100 μM phosphate buffer and plated on Trypticase soy agar plates. The plates were incubated at 37°C for 24 h and then counted for viable CFUs of bacteria for the biocidal efficacy analysis.

RESULTS AND DISCUSSION

Characterization of the coatings

BTCA and AMP were dissolved in water and applied onto cotton fabric according to the procedure described previously. When heat was applied, BTCA formed cyclic anhydride structures,³⁵ which then reacted with the NH_2 group of AMP and the OH groups of cellulose (Fig. 1). The coating on the cotton fabric was characterized by ATR-IR spectroscopy (Fig. 2). As shown, when only 3.5 wt % BTCA was coated onto cotton [Fig. 2(B)], the carbonyl stretching mode was obtained at 1722 cm^{-1} .^{38,39} On the other hand, when AMP and BTCA were coated together [Fig. 2(C)], a new band at 1696 cm^{-1}

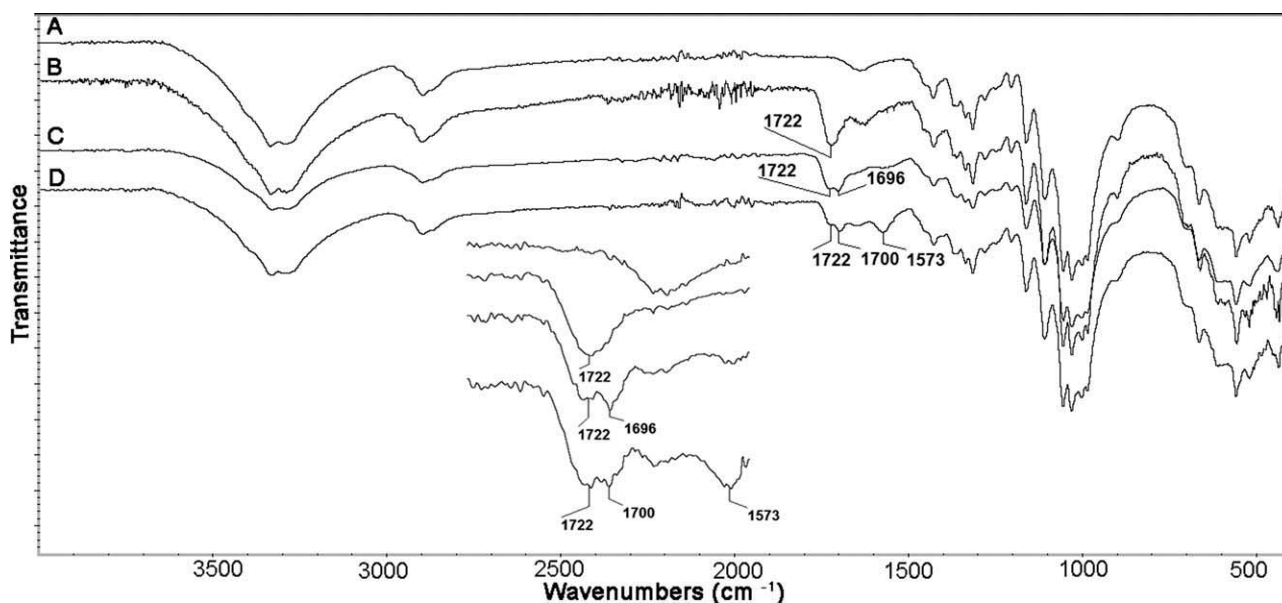


Figure 2 ATR-IR characterization of the coating on cotton fabric: (A) cotton fabric, (B) BTCA-coated cotton fabric (3.5 wt %), (C) BTCA- (3.5 wt %) and AMP- (1.5 wt %) coated cotton fabric, and (D) BTCA (3.5 wt %) and AMP (1.5 wt %) chlorinated coated cotton fabric.

appeared; this indicated amide formation between BTCA and AMP. This vibrational band shifted to a slightly higher wave number upon chlorination [Fig. 2(D)]; this signified the disruption of $N-H \cdots O=C$ hydrogen bonding as a conversion of $N-H$ to $N-Cl$ occurred.⁴⁰ Furthermore, upon chlorination, some acid groups of BTCA were converted into carboxylate anion, which exhibited a vibrational band at 1573 cm^{-1} .³⁶

Anhydrides are known to preferentially react with amine groups as opposed to hydroxyls.⁴¹ Thus, when BTCA formed the anhydride, it then reacted with the amine group rather than the hydroxyl group of AMP because amines are stronger nucleophiles than alcohols are.³⁹ To address the reaction pathway, AMP and BTCA were reacted in *N,N*-dimethylacetamide, as described in the Experimental section, and then characterized by ATR-IR and NMR spectroscopies. The ATR-IR spectra of AMP, BTCA, and their product are shown in Figure 3. In these spectra, 1592 cm^{-1} [Fig. 3(A)] and 1692 cm^{-1} [Fig. 3(B)] corresponded to the amine bending mode of AMP and the carbonyl stretching mode of BTCA, respectively.^{36,42} When AMP and BTCA were reacted [Fig. 3(C)], the amine bending mode disappeared, and a new band around 1643 cm^{-1} , corresponding to the amide stretching mode, appeared.⁴³ On the other hand, the band corresponding to the carbonyl stretching mode of BTCA shifted slightly to a higher wave number. The C—O stretching mode of the primary alcohol moiety present in AMP was observed at 1050 cm^{-1} . NMR spectra of the product also supported the formation of an amide bond

rather than ester bonding of AMP and BTCA. As shown in the ^{13}C -NMR spectra (Fig. SP3, Supporting Information), upon reaction, the signal for the tertiary carbon atom of AMP shifted downfield (from 52 to 57 ppm) because of reduced electron density, whereas the methylene group signal of AMP shifted upfield (from 73 to 68 ppm); this further signified that the reaction took place through the amine group.

TGA data of the untreated and treated cotton fabrics are shown in Figure 4. As expected, the AMP/BTCA treatment lowered the thermal decomposition temperature (from 348 to 339°C) and increased the char amount (from 7 to 12%) because crosslinking imparted a higher thermal stability.³⁴ When the coated samples were chlorinated, the thermal decomposition temperature decreased even more (to 330°C) because the chlorination process weakened the fabric. Furthermore, the chlorinated samples exhibited higher percentage residue (18%) than the unchlorinated samples, as observed in a previous *N*-halamine study.⁴⁴

Washing stability

The stability and durability of the coatings toward repeated laundering were determined through measurement of the remaining chlorine content of the swatches, as shown in Table I. In this table, the X column represents the swatches chlorinated only before the washing tests, the Y column shows the swatches chlorinated both before and after the washing tests, and the Z column demonstrates the

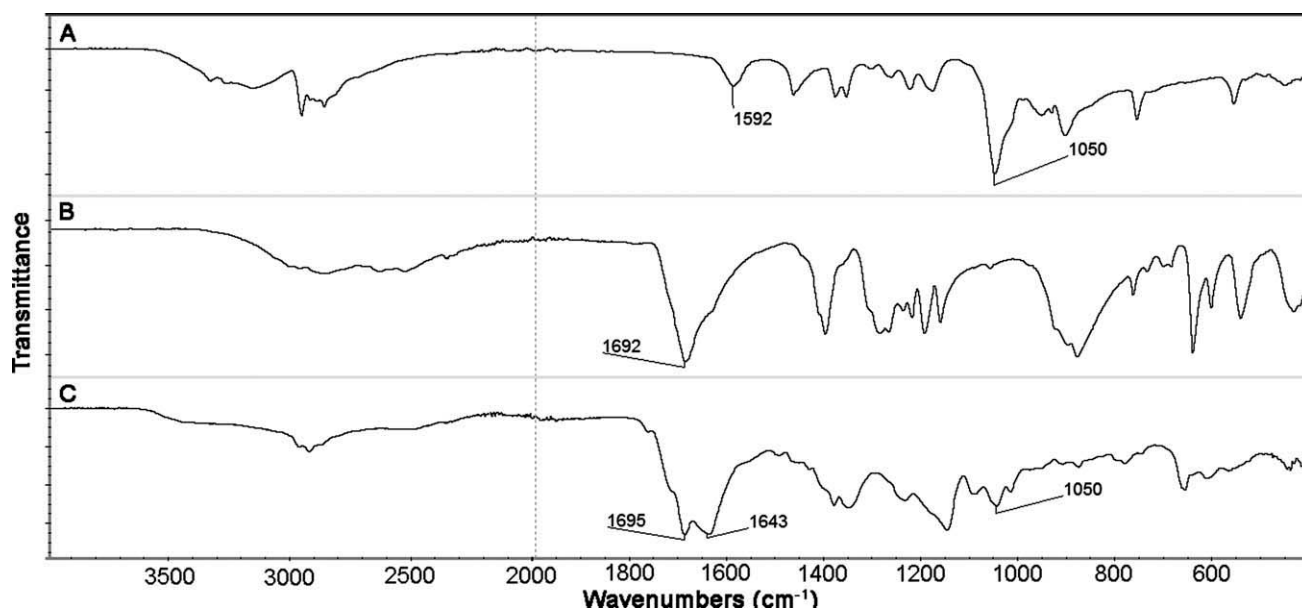


Figure 3 ATR-IR spectra of (A) AMP, (B) BTCA, and (C) 2,3-bis[2-[(1-hydroxyl-2-methylpropan-2-yl)amino]-2 oxoethyl]-succinic acid.

swatches chlorinated only after the washing tests. Two different sets of experiments were performed to observe the effect of the BTCA content on the washing stability and durability. In the first experiment, 5 wt % (1.5% AMP + 3.5% BTCA) coated swatches were evaluated, and in the second experiment, 7.5 wt % (1.5% AMP + 6% BTCA) coated samples were evaluated. In general, the coating of AMP, together with BTCA, exhibited promising stability toward repeated laundering (Table I, X column), such that more than 50% of the initial chlorine remained even after 50 washing cycles. ATR-IR analysis of the swatches exposed to 50 laundering cycles supported the existence of the coating (Fig. SP4, Supporting Information). Although AMP is an acyclic *N*-halamine precursor, the stabilities of the coatings were even better than some of the previously reported cyclic *N*-halamines attached onto cotton fabric with different tethering groups.^{23,29,30,45,46} A possible reason for this superior stability might have been the existence of crosslinked structures, both on the inner and outer surfaces, of the cotton fiber, which protected the coatings from excessive mechanical effects of the washing cycles. When the swatches shown in the X column were rechlorinated (Y column), the remaining chlorine contents increased substantially; this showed that the chlorine loss with increasing washing cycles in column X was due mostly to N-Cl bond dissociation rather than the coating being hydrolyzed away from the surface. In both cases, durability in the Y column was preferable to that in the Z column because prechlorination rendered the surface more hydrophobic, which then reduced the hydrolysis effects reported

earlier in some other studies.^{25,47} When the BTCA content in the coating solution was increased, the durability of the coating improved significantly as expected because increased crosslinking on the surface shielded the *N*-halamine moiety from washing mechanical effects. This shielding effect was also observed during titration, as the oxidative chlorine reacted more slowly when the BTCA content was higher.

UVA light stability

The stability of the coatings toward UVA light exposure is illustrated in Table II. The BTCA amount in the coating solution was varied to observe the effect

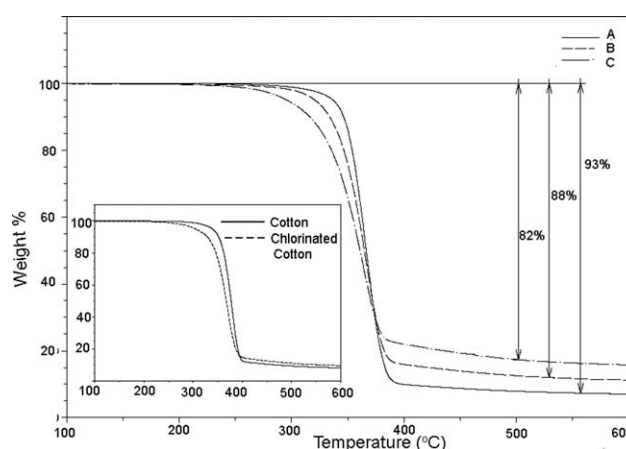


Figure 4 TGA of the (A) cotton fabric, (B) 5 wt % AMP/BTCA-coated cotton fabric, and (C) 5 wt % AMP/BTCA chlorinated coated cotton fabric.

TABLE I
Stability and Durability Toward Washing of the Coatings on the Cotton Fabric (Cl⁺ % Remaining)

Number of machine washes ^a	5 wt % coated (1.5% AMP + 3.5% BTCA)			7.5 wt % coated (1.5% AMP + 6% BTCA)		
	X	Y	Z	X	Y	Z
0	0.32			0.33		
5	0.23	0.32	0.28	0.27	0.31	0.32
10	0.20	0.31	0.26	0.26	0.32	0.30
25	0.18	0.29	0.24	0.18	0.32	0.30
50	0.17	0.26	0.23	0.18	0.32	0.29

^a A washing cycle was equivalent to five normal machine washings in AATCC test method 61. X, chlorinated before washing; Y, chlorinated before washing and rechlorinated after washing; Z, unchlorinated before washing but chlorinated after washing.

of the crosslinking density. For the chlorinated (5 wt % coated swatches) exposed to UVA light, all of the oxidative chlorine was lost within 24 h of exposure. When samples exposed for 24 and 48 h were rechlorinated, around 50 and 30% of the initial chlorine loading were restored, respectively; this revealed that the chlorine lost was due to both N–Cl bond dissociation and decomposition taking place in the structure. On the other hand, no decomposition was observed for the unchlorinated samples chlorinated at the end of 24 h of UVA exposure, whereas 35% decomposition was detected when the samples were chlorinated at the end of 48 h of UVA exposure. This observation led to the conclusion that unlike previously studied *N*-halamine coatings,⁴⁸ a slight photodecomposition of the coating took place under UVA light exposure, even without the coating being chlorinated. This decomposition was also detected by ATR–IR analysis of the UV irradiated samples (Fig. SP5, Supporting Information), and the mechanism for this photodecomposition is under study. Increased BTCA amount (7.5 wt % coated) resulted in a slower chlorine loss and a lesser magnitude of photodecomposition, but in general, the same trend as in the 5 wt % coated swatches was observed.

Storage stability

The storage stability of the coatings in sealed conditions was evaluated by measurement of the remaining chlorine contents of the bleached swatches over a 60-day period (Table III). Two sets of 5 wt % coated swatches were stored in a conditioning room (21°C, 65% relative humidity); one set was placed under a laboratory light on a bench, and the other was stored in a dark environment. Swatches stored in darkness retained around 70 and 50% of the initial chlorine loading at the end of 30 and 60 days, respectively, whereas the swatches stored under laboratory lighting lost almost all of the chlorine within 30 days. However, upon rechlorination, 90% of the initial chlorine was restored; this revealed that the loss was primarily due to dissociation of the N–Cl bond rather than polymer decomposition. Overall, the storage stability in this work was comparable to cyclic *N*-halamine coatings studied previously.⁴⁹

Wrinkle recovery measurement and mechanical testing

A sufficient chlorine loading of about 0.30 wt % for an effective biocidal efficacy³⁰ could be reached with

TABLE II
Stability Toward UVA Light Exposure of the Coatings on the Cotton Fabric (Cl⁺ % Remaining)

Exposure time (h)	7.5 wt % Coated (1.5% AMP + 6% BTCA)			
	Chlorinated	Unchlorinated	Chlorinated	Unchlorinated
0	0.29		0.26	
1	0.08		0.13	
2	0.07		0.10	
3	0.05		0.09	
6	0.02		0.05	
12	0.01		0.03	
24	0		0.02	
Rechlorination	0.15	0.29	0.18	0.27
48	0		0.01	
Rechlorination	0.10	0.19	0.15	0.23

TABLE III
Storage Stability of 5 wt % (1.5% AMP + 3.5% BTCA)
Coated Cotton Fabric (Cl⁺ % Remaining)

Number of days	Laboratory light storage	Dark storage
0	0.34	0.34
5	0.19	0.29
10	0.13	0.28
14	0.09	0.26
20	0.05	0.25
25	0.03	0.24
30	0.02	0.24
Rechlorination	0.30	nd ^a
60	0.04	0.16
Rechlorination	0.24	0.33

^a nd, not determined.

the presence of 1.5 wt % AMP in the coating solution. Therefore, the BTCA concentration in the coating solution varied from 1.5 to 9 wt % with a constant 1.5 wt % AMP in the coating solution, and the WRAs of the coated swatches were measured. As can be seen in Figure 5, increasing the BTCA concentration in the coating solution increased the WRA exponentially, as reported previously.^{38,50}

The mechanical test and WRA measurement results are summarized in Table IV. Both the tensile and tear loads decreased dramatically when the cotton fabric was treated with only 6 wt % BTCA. This loss was due to intramolecular crosslinking in the fibers (reversible loss) and depolymerization of the cellulose macromolecules by the acidity of the treatment solution³⁷ (pH = 1.9); this has been observed in several other studies.^{34,36,50} Interestingly, the addition of AMP (1.5 wt %) to the coating solution improved the strength retention tremendously. This was probably due to reduced acidity of the coating solution in the presence of AMP (pH 3.2) and the lesser amount of crosslinking, as evidenced by the lower WRA. When the AMP/BTCA-treated fabric was exposed to bleach, the strength retention was further enhanced because NaOH present in the

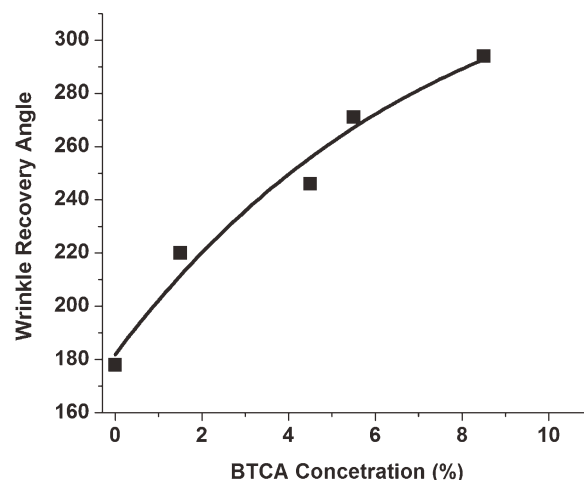


Figure 5 Effect of the BTCA concentration on WRA.

bleaching solution destroyed some of the ester linkages between cellulose and BTCA and led to reduced intramolecular crosslinking. However, this increase was small and revealed that the strength loss at that curing condition was due mostly to the acidity of the treatment solution.

Biocidal efficacy tests

The unchlorinated-treated and chlorinated-treated cotton swatches (1.5 wt % AMP + 3.5 wt % BTCA) were challenged with *E. coli* O157:H7 and *S. aureus* at concentrations of around 10⁶ CFU, and the results are summarized in Table V. The chlorinated swatches inactivated all of the Gram-negative and Gram-positive bacteria within 5 min of contact time. The unchlorinated control swatches did not exhibit any significant biocidal efficacy with 0.17 log *E. coli* O157:H7 and 0.52 log *S. aureus* reductions within 30 min of contact time. This limited degree of reduction was due to the adhesion of the bacteria to the fabric surfaces.⁴⁶ Previous studies in these laboratories showed that comparable biocidal efficacies were

TABLE IV
Mechanical Testing and WRA Measurement Results of 7.5 wt % Coated (1.5% AMP + 6% BTCA) Cotton Fabrics

	Tensile breaking load (N)		Tensile elongation at break (%)		Average tear load (N) Weft	WRA (c + f) ^f
	Weft ^d	Warp ^e	Weft	Warp		
Untreated	173	279	21.2	5.4	5.25	198
BTCA coated ^a	54	152	17.9	3.1	0.82	296
BTCA + AMP coated ^b	74	216	18.4	3.5	1.07	280
BTCA + AMP coated-Cl ^c	83.5	225	18.2	3.7	1.35	273

^a Treated with only 6 wt % BTCA.

^b Treated with 7.5 wt % AMP/BTCA (1.5% AMP + 6% BTCA).

^c Treated with 7.5 wt % AMP/BTCA (1.5% AMP + 6% BTCA) and then chlorinated.

^d Widthwise.

^e Lengthwise.

^f Sum of the WRA in the weft (f) and warp (c) directions.

TABLE V
Biocidal Test Results of the 5 wt % (1.5% AMP + 3.5% BTCA) Coated Cotton Fabrics

	Contact time (min)	<i>E. coli</i> O157:H7 ^a		<i>S. aureus</i> ^b	
		%	Log reduction	%	Log reduction
Control	30	31.7	0.17	69.7	0.52
Chlorinated	5	100	6.72	100	6.25
Cl ⁺ (%) 0.32	10	100	6.72	100	6.25
	30	100	6.72	100	6.25

^a The inoculum concentration was 6.72 log.

^b The inoculum concentration was 6.25 log.

obtained when the chlorine loading was around 0.30 wt %.⁵¹ Because 7.5 wt % coated swatches provided around the same chlorine loadings, we expect to have equally effective biocidal efficacy when the BTCA concentration is higher.

CONCLUSIONS

AMP was coated onto cotton fabric with BTCA as a crosslinking agent. BTCA not only acted as a crosslinking agent between the fabric and AMP but also improved the WRA of the cotton fabric. The coating was rendered biocidal upon bleach exposure; it exhibited highly efficient antimicrobial functionality against *E. coli* O157:H7 and *S. aureus*, providing complete kill within 5 min of contact time. Only 1.5 wt % AMP was sufficient for this effective biocidal efficacy. The coating was also very stable and durable toward repeated laundering. Even though a photolytic decomposition was observed upon exposure to UVA light, the coating exhibited sufficient storage stability for industrial use. The coating of cotton fabric with AMP/BTCA has industrial potential because very effective antimicrobial and durable-press functionalities could be imparted by coating an inexpensive *N*-halamine precursor via a fairly simple procedure.

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