

Fabric Properties of Butadienediepoxyde-Treated Cottons as Affected by Liquid Ammonia Pretreatments

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Synopsis

Effects of liquid ammonia and mercerizing-strength caustic as pretreatments upon textile properties of cotton sheeting modified with butadienediepoxyde (BDO) catalyzed by 2% and 15% NaOH were compared. Tensile properties of the NaOH-mercerized control (CM) (celluloses I and II) greatly exceeded those of native (cellulose I) and ammonia-treated (NH_3) controls. NH_3 (I) and NH_3 (III) are those cottons having the cellulose I and mixed celluloses I and III lattices, respectively. Resistance to flex abrasion was doubled by pretreatments. Wrinkle recoveries of all controls were equivalent, but tensile recovery differed. BDO reaction enhanced wrinkle recovery of controls but produced the usual losses in tensile properties and resistance to flex abrasion associated with crosslinking reagents. BDO reaction nullified the initial tensile advantage held by CM cotton. Tear strengths of all BDO-treated cottons remained comparable. High dry and high wet recoveries were obtained only when 2% NaOH catalyzed the BDO reaction and were greatest for NH_3 cottons. BDO reaction reduced permanent set of all controls and increased tensile recovery primarily by enlarging the delayed recovery. Postmercerization with 23% NaOH adversely affected recovery behavior of all BDO-treated cottons. Nevertheless, wrinkle and tensile recoveries of postmercerized NH_3 (I) and CM cottons were equivalent. Postmercerization partially restored fabric properties of BDO cottons with cellulose I lattice to those of their respective controls; no change was noted for corresponding products from CM cottons. Because of this, final properties of products from NH_3 (I) cottons equaled and even exceeded those of comparable CM cottons.

INTRODUCTION

There is a growing interest in the commercial use of liquid ammonia to replace conventional NaOH mercerization (CM) as pretreatment in the chemical modification of cotton. While conventional mercerizations result in cottons with mixed celluloses I and II crystalline lattices, liquid ammonia pretreatments result in a cellulose I or cellulose III lattice, depending on the method of removal of ammonia.¹ Previous work showed that final fabric properties depended on the crystalline lattice of cellulose at the time of its chemical modification with BDO.^{2,3} Therefore, BDO was selected in a study designed to compare effects of "liquid ammonia mercerization" with conventional NaOH mercerization. In addition, BDO was selected because it can be effectively applied in basic media to impart excellent easy care properties⁴ and the ether bonds formed with cellulose are stable to subsequent basic treatments.

TABLE I
Treatment Conditions for BDO Reaction of Cotton Sheeting^a

Sample and symbol Add-ons	Native cotton		Mercerized cotton CM		Ammonia cellulose			
	Low	High	Low	High	NH ₃ (I)		NH ₃ (III)	
					Low	High	Low	High
Catalyst								
2% NaOH	13	20	11	26	11	25	7	17
15% NaOH	13	28	13	25	10	30	11	23
Postmercerized with 23% NaOH		√ ^b		√		√		X Insufficient sample

^a Four oz/yd² desized, scoured, and bleached sheeting before and after conventional mercerization with 23% NaOH (CM) or after liquid ammonia treatments to yield a Cell I or III lattice; each fabric treated with 2% or 15% aqueous base and then reacted with CCl₄ solution of butadiene diepoxide (BDO) to give indicated add-ons of BDO in wt-%.

^b √ = Fabrics were postmercerized. X = not postmercerized.

EXPERIMENTAL

Desized, scoured, and bleached cotton sheeting (4 oz/yd²) was pretreated slack with aqueous 23% NaOH or with liquid NH₃¹ and subsequently reacted with BDO.^{1,2,3}

Physical properties tested according to standard ASTM procedures were thread count^{5a}; strip breaking strength, elongation at break and energy to rupture^{5b}; Elmendorf tear strength^{5c}; resistance to flex abrasion^{5d}; and conditioned wrinkle recovery.^{5e}

Wet wrinkle recovery was determined by the method of Fujimoto⁶ and tensile recovery, by the method of Susich and Backer.⁷

RESULTS AND DISCUSSION

Table I summarizes treatment conditions for fabrics used in this report.¹ Thread count (Table II) showed that greatest shrinkage occurred in conventional mercerization of native cotton. Only minor shrinkage in the filling direction resulted from "ammonia mercerization." Although in slack condition when immersed in the liquid ammonia, the fabric developed some tension upon emerging from the treating bath and passing over the rolls of the chainless mercerizer, thereby accounting for limited shrinkage. With 2% NaOH catalyst, BDO reaction caused no further shrinkage of respective controls. However, with BDO and 15% NaOH catalyst, thread counts increased slightly in both directions for BDO products derived from cottons having a cellulose I lattice but increased only in the filling direction for BDO products from CM or NH₃(III) cottons. Net shrinkage after BDO reaction was greatest in products from CM cotton. In general, postmercerization with 23% NaOH of BDO products caused no further shrinkage.

Differences in breaking strength before and after BDO reaction are shown in Figure 1. Initial values for native and NH₃-treated cottons were equivalent but significantly less than that of the CM control. BDO reaction caused

TABLE II
Shrinkage Associated with Treatments
as Indicated by Thread Count of 4-oz Cotton Sheeting

Lattice type Direction	Controls								
	Native		Mercerized		NH ₃ (I)		NH ₃ (III)		
	I		I & II		I		I & III		
	W	F	W	F	W	F	W	F	
Treatment ^a									
C	85	72	105	89	90	75	96	72	
C + 2 + L	88	77	100	91	90	75	92	74	
C + 2 + H	87	76	99	91	92	74	93	74	
C + 15 + L	92	83	105	93	95	80	97	81	
C + 15 + H	93	83	105	95	96	81	97	83	
Postmercerized Specimens									
C + M*	105	89	—	—	94	73			
C + 2 + H + M*	88	77	102	95	93	83	Insufficient sample		
C + 2 + H + M*	93	82	101	93	93	76			
C + 15 + L + M*	95	89	106	94	97	86			
C + 15 + H + M*	93	86	103	94	95	81			

^a C, Respective control cotton; 2 and 15 indicate concentrations of NaOH used as catalysts; L and H represent low and high add-ons (as shown in Table I) of butadiene-diepoide; M* represents a postmercerization with 23% NaOH.

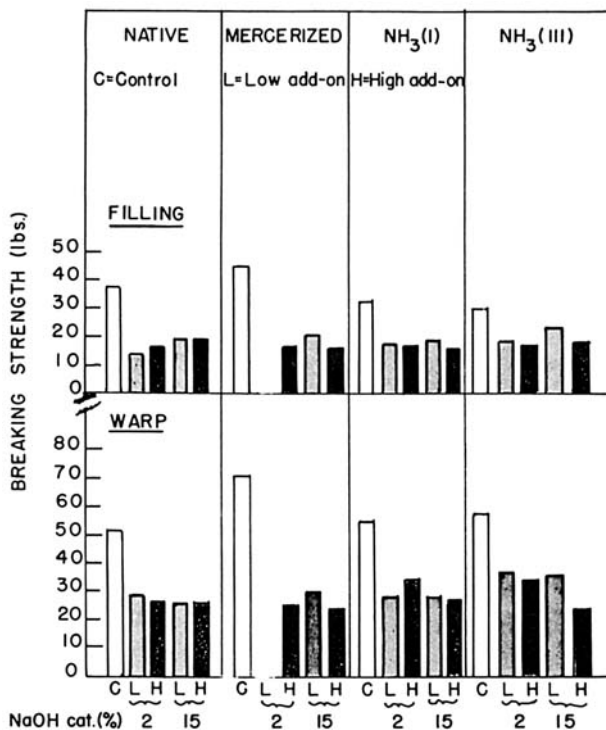


Fig. 1. Effects of pretreatments, concentration of base catalysts, and add-ons of butadiene-diepoide (BDO) on breaking strengths of 4 oz/yd² cotton sheeting. Cotton treated as such—native control—or premercerized with 23% NaOH or liquid NH₃ to yield cellulose lattice structures II, I, or III as indicated.

TABLE III
Effect of Postmercerization Upon Breaking Strength^a

Control	Breaking strength, lbs					
	Native		Mercerized		NH ₃ (I)	
	W = 51.8	F = 36.4	W = 71.2	F = 44.7	W = 53.6	F = 32.3
	2% NaOH					
Warp	BDO	BDO + M*	BDO	BDO + M*	BDO	BDO + M*
Low	27.3	28.8	—	—	28.2	39.6
High	25.5	38.0	24.1	21.7	33.9	36.3
Fill						
Low	13.6	15.5	—	—	17.6	22.6
High	16.2	22.0	16.8	12.0	15.4	16.8
	15% NaOH					
Warp						
Low	25.4	34.7	29.1	29.9	27.3	32.4
High	26.1	27.6	23.2	20.3	26.2	26.3
Fill						
Low	18.9	24.8	19.3	20.4	18.3	20.8
High	17.7	15.8	15.6	9.1	15.1	12.5

^a Cotton as indicated control reacted with CCl₄ solutions of butadienediepoide (BDO) catalyzed by 2% or 15% NaOH to yield high and low add-ons of BDO; M* is each BDO-treated fabric after a postmercerization with aqueous 23% NaOH.

TABLE IV
Effect of Postmercerization on Elongations at Break^a

Control	Elongation at Break (%)					
	Native		Mercerized		NH ₃ (I)	
	W = 10.5	F = 23.3	W = 22.6	F = 44.8	W = 7.0	F = 27.9
	2% NaOH					
	BDO	BDO + M*	BDO	BDO + M*	BDO	BDO + M*
Warp						
Low	5.3	6.3	—	—	5.5	15.3
High	5.7	13.9	12.6	15.3	4.4	8.7
Fill						
Low	13.9	16.0	—	—	21.5	26.4
High	18.4	23.6	20.8	18.6	19.1	20.7
	15% NaOH					
Warp						
Low	14.2	24.0	21.9	21.8	13.9	19.6
High	15.6	17.7	20.0	17.6	12.8	11.5
Fill						
Low	24.7	28.9	33.5	34.3	27.1	29.1
High	24.4	22.0	28.4	20.9	23.0	21.7

^a Cotton as indicated control reacted with CCl₄ solutions of butadienediepoide (BDO) catalyzed by 2% or 15% NaOH to yield high and low add-ons of BDO; M* is each BDO-treated fabric after a postmercerization with aqueous 23% NaOH.

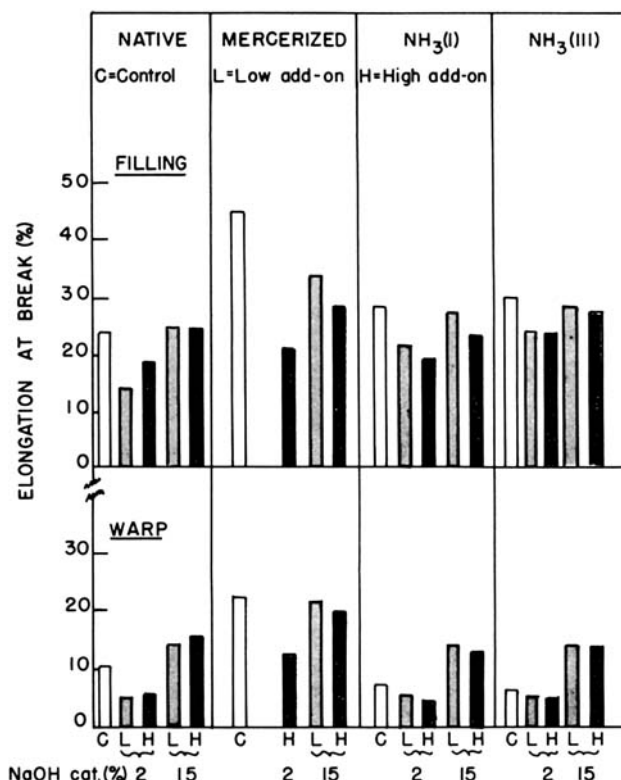


Fig. 2. Effects of pretreatments, concentration of base catalysts, and add-ons of butadienediepoxyde (BDO) on elongations at break of 4 oz/yd² cotton sheeting. Cotton treated as such—native control—or premercerized with 23% NaOH or liquid NH₃ to yield celluloses II, I, or III as indicated.

a significant loss with respect to each control, and each loss was about equal in warp and fill directions. However, BDO products from CM cottons retained only 35% of their original strength while those from native and NH₃-treated cottons retained between 50% and 60%. Despite this fact, absolute strengths of all BDO products were of the same order of magnitude, with those from NH₃(I) and NH₃(III) being slightly greater in the warp direction only. Breaking strength seemed independent of catalyst concentration and of BDO add-on.

Postmercerization of BDO-treated cottons (Table III) generally increased breaking strengths of products from native and NH₃(I) cottons but had either no effect or reduced strengths of products from CM cotton. Following postmercerization, breaking strengths of products from native and NH₃(I) cottons were comparable and even exceeded those of products from the CM control.

Figure 2 illustrates changes in elongation at break accompanying the various treatments. With respect to native cotton, CM cotton had significantly increased elongation in both directions, while NH₃(I) and NH₃(III) had increased elongation in the filling but reduced elongation in the warp direction. The effect of BDO varied with the control cotton and concentration of the

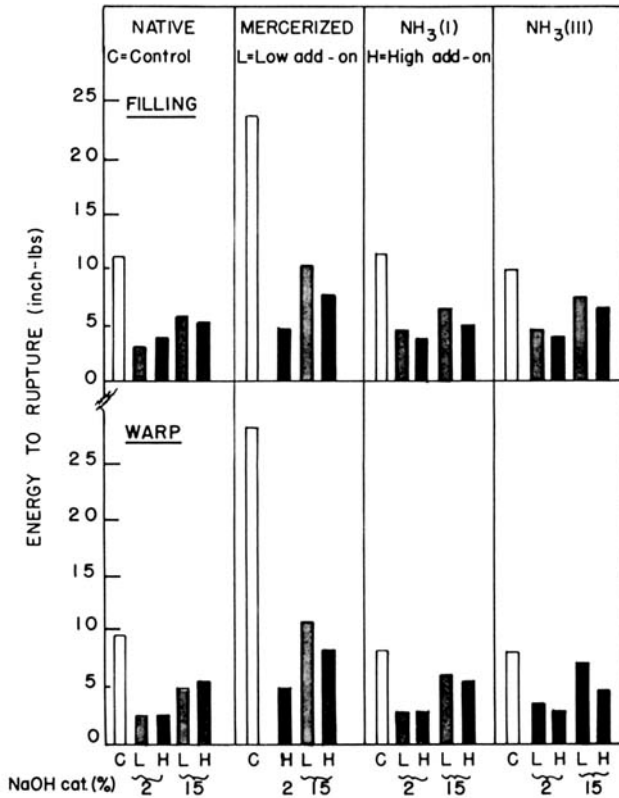


Fig. 3. Effects of pretreatments, concentration of base catalysts, and add-ons of butadiene-epoxide (BDO) on energy to rupture of 4 oz/yd² cotton sheeting. Cotton treated as such—native control—or premercerized with 23% NaOH or liquid NH₃ to yield celluloses II, I, or III as indicated.

base. With 2% NaOH, BDO reduced elongations at break of each control in both directions. With 15% NaOH, the effect of BDO upon elongation differed in warp and filling yarns of each control. In the warp direction, BDO reaction had no effect on elongations of CM cotton, but significantly increased elongation of native, NH₃(I) and NH₃(III) cottons. In the filling direction, BDO reaction catalyzed by 15% base had least effect upon native and most effect on CM cottons.

Postmercerization with 23% NaOH had virtually no effect upon elongation at break of BDO products from CM cotton, but restored those of products from native and NH₃(I) cottons to control values (Table IV). As a result, elongations of postmercerized BDO-treated native or NH₃ cottons were comparable to those of corresponding BDO-treated CM cottons.

The area under a load-elongation curve measures energy to rupture and, thus, reflects a composite effect of breaking strength-elongation changes accompanying chemical modification. Data in Figure 3 show that with respect to native cotton, this energy was much greater for CM cotton and only a little less for NH₃(I) or NH₃(III) cottons. BDO reaction significantly reduced all energies to rupture, and relative to each control, the loss was greatest in CM products. Generally, within each set of BDO-treated fabrics, energy losses

TABLE V
Effect of Postmercerization on Energy to Rupture^a

Control	Energy to rupture, in.-lb					
	Native		Mercerized		NH ₃ (I)	
	W = 12.1	F = 15.2	W = 23.4	F = 22.1	W = 9.1	F = 13.7
Treatment	2% NaOH					
	BDO	BDO + M*	BDO	BDO + M*	BDO	BDO + M*
Warp						
Low	2.8	3.5	—	—	3.1	9.6
High	2.9	8.1	4.5	4.9	2.9	5.3
Fill						
Low	2.9	3.8	—	—	5.8	6.6
High	3.0	7.0	4.1	3.1	4.8	5.1
	15% NaOH					
Warp						
Low	5.3	10.8	8.9	8.8	6.0	9.0
High	5.8	6.9	6.8	5.9	5.4	4.9
Fill						
Low	5.3	8.1	8.4	8.3	7.1	7.4
High	5.8	5.0	6.1	3.3	5.6	4.2

^a Cotton as indicated control reacted with CCl₄ solutions of butadienediepoide (BDO) catalyzed by 2% or 15% NaOH to yield high and low add-ons of BDO; M* is each BDO-treated fabric after a postmercerization with aqueous 23% NaOH.

TABLE VI
Effect of Postmercerization on Tear Strength^a

Control	Tear strength, g					
	Native		Mercerized		NH ₃ (I)	
	W = 1200	F = 883	W = 1367	F = 383	W = 1200	F = 800
Treatment	2% NaOH					
	BDO	BDO + M*	BDO	BDO + M*	BDO	BDO + M*
Warp						
Low	400	417	—	—	413	767
High	450	800	300	300	567	613
Fill						
Low	200	450	—	—	427	380
High	233	350	150	200	167	213
	15% NaOH					
Warp						
Low	583	1167	550	483	613	760
High	517	517	383	400	520	507
Fill						
Low	383	450	283	317	300	353
High	317	333	183	217	233	253

^a Cotton as indicated control reacted with CCl₄ solutions of butadienediepoide (BDO) catalyzed by 2% or 15% NaOH to yield high and low add-ons of BDO; M* is each BDO-treated fabric after a postmercerization with aqueous 23% NaOH.

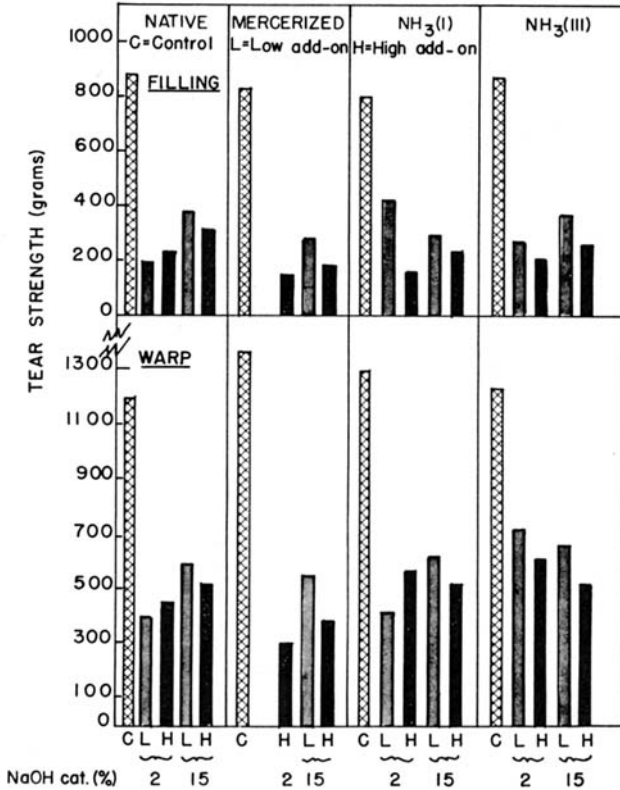


Fig. 4. Effects of pretreatments, concentration of base catalysts, and add-ons of butadiene-epoxide (BDO) on tear strength of 4 oz/yd² cotton sheeting. Cotton treated as such—native control—or premercerized with 23% NaOH or liquid NH₃ to yield celluloses II, I, or III as indicated.

were relatively insensitive to add-on but were less with the stronger base catalyst. Energies to rupture postmercerized BDO products from native and NH₃(I) cottons were comparable or higher than those from CM cotton (Table V). Tearing strengths of all controls did not differ significantly, although that of CM cotton in the warp direction was slightly greater than the rest. BDO reaction significantly reduced tearing strength of each control (Fig. 4). Although numerical values for all BDO products were of the same order of magnitude, tearing strengths of BDO-treated native and NH₃-treated cottons were slightly greater than those of corresponding products from CM cotton. In general, tearing strength losses were greater with 2% NaOH than with 15% NaOH catalyst. Postmercerization (Table VI) tended to increase tearing strengths of BDO products from native and NH₃(I) controls but had no further effect upon those of products from CM cotton. Even though increases were generally slight, absolute tearing strengths of the former BDO products tended to exceed those of comparable products from CM cotton.

Conventional and "ammonia mercerization" increased resistance to flex abrasion significantly in both directions and to essentially equivalent extents (Table VII). BDO reaction virtually destroyed flex abrasion resistance of all controls, and postmercerization had little if any further effect.

TABLE VII
Flex Abrasion Resistance of Controls and Chemically Modified Cottons^a

Sample Direction Units	Native		Mercerized		Ammonia-treated			
					NH ₃ (I)		NH ₃ (III)	
	W	F	W	F	W	F	W	F
Control (C)	613	453	1449	1181	1064	699	1359	1058
C + 2 + BDO-L	40	26	50	40	92	61	138	91
C + 2 + BDO-H	47	31	38	37	28	23	44	40
C + 15 + BDO-L	112	74	285	239	293	114	400	230
C + 15 + BDO-H	105	78	160	103	63	46	134	61
Control (C-M*)	1449	1181	—	—	1087	822	—	—
C + 2 + BDO-L-M*	42	45	75	73	270	159	—	—
C + 2 + BDO-H-M*	122	97	51	37	45	29	—	—
C + 15 + BDO-L-M*	371	204	307	244	393	287	—	—
C + 15 + BDO-H-M*	82	66	118	80	55	38	—	—

^a Cotton as indicated control reacted with CCl₄ solutions of butadienediepoide (BDO) catalyzed by 2% or 15% NaOH to yield high and low add-ons of BDO; 2 = 2% NaOH catalyst; 15 = 15% NaOH catalyst; BDO-L = treated with BDO to low add-on; BDO-H = treated with BDO to high add-on; M* is each treated fabric after a postmercerization with aqueous 23% NaOH.

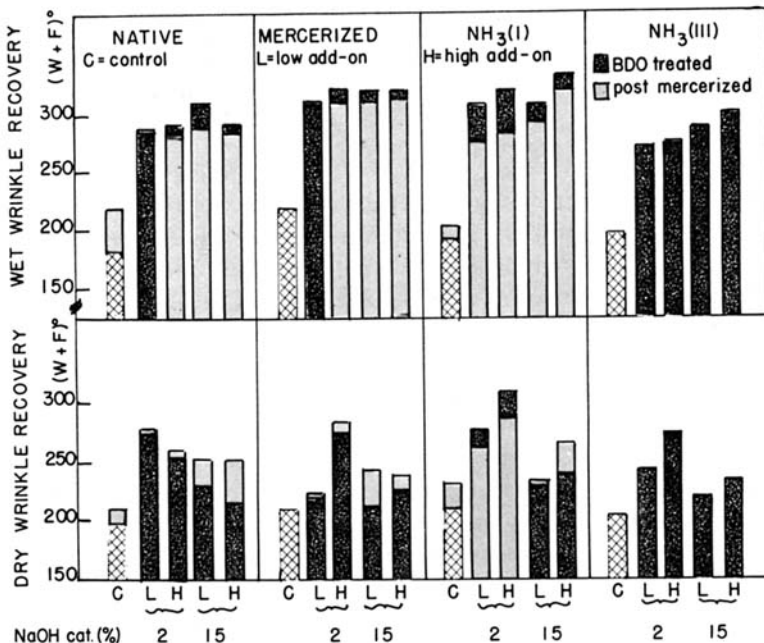


Fig. 5. Effects of pretreatments, concentration of base catalysts, and add-ons of butadienediepoide (BDO) on wrinkle recovery of 4 oz/yd² cotton sheeting, and effect of postmercerization upon wrinkle recoveries of BDO-treated cottons. Cotton treated as such—native control—or premercerized with 23% NaOH or liquid ammonia to yield celluloses II, I, or III as indicated

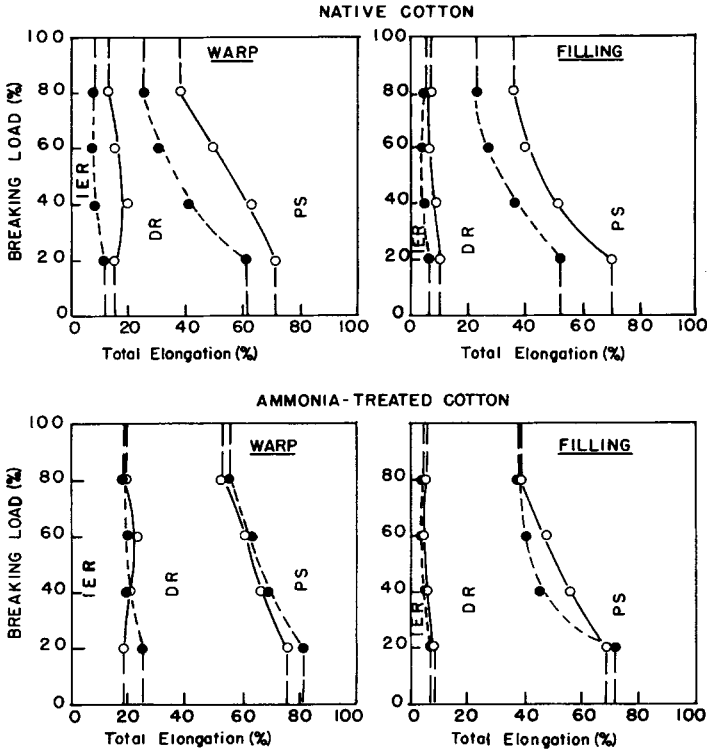


Fig. 6. Effects of NaOH or liquid NH_3 mercerizations upon tensile recovery of 4 oz/yd² cotton sheeting. Upper graphs: (O) native cotton; (●) native cotton after mercerization with 23% NaOH. Lower graphs: (O) native cotton after treatment with liquid NH_3 to yield either cellulose I or cellulose III; (●) NH_3 -treated cottons after mercerization with 23% NaOH. IER = Immediate elastic recovery; DR = delayed recovery; PS = permanent set.

None of the control cottons possessed high dry or wet recovery angles (Fig. 5). High dry and high wet wrinkle recoveries resulted only when 2% NaOH was used with BDO. With 15% NaOH catalyst, only high wet recovery resulted. Wet wrinkle recoveries were independent of catalyst strength. With 2% NaOH, dry and wet wrinkle recoveries of BDO products from NH_3 (I) exceeded those of comparable products from native and NH_3 (III) controls. However, only dry recovery angles of products from NH_3 (I) exceeded those of comparable products from the CM control; wet recoveries of these products were equivalent. Thus, under 2% NaOH catalysts, BDO products from NH_3 (I) cotton had the greatest dry and wet wrinkle recoveries. Although reduced by postmercerization, wet recovery angles of all BDO products remained high. On the other hand, dry recovery was significantly reduced by postmercerization only in products prepared from NH_3 (I) with 2% NaOH. Dry recoveries of all other BDO products prepared with 2% NaOH catalyst were not significantly affected by postmercerization, and those of BDO products prepared with 15% NaOH were increased. Nevertheless, even after postmercerization, only products prepared with 2% NaOH as catalyst had high dry and high wet wrinkle recoveries.

Tensile recovery, the ability to recovery from deformation when applied

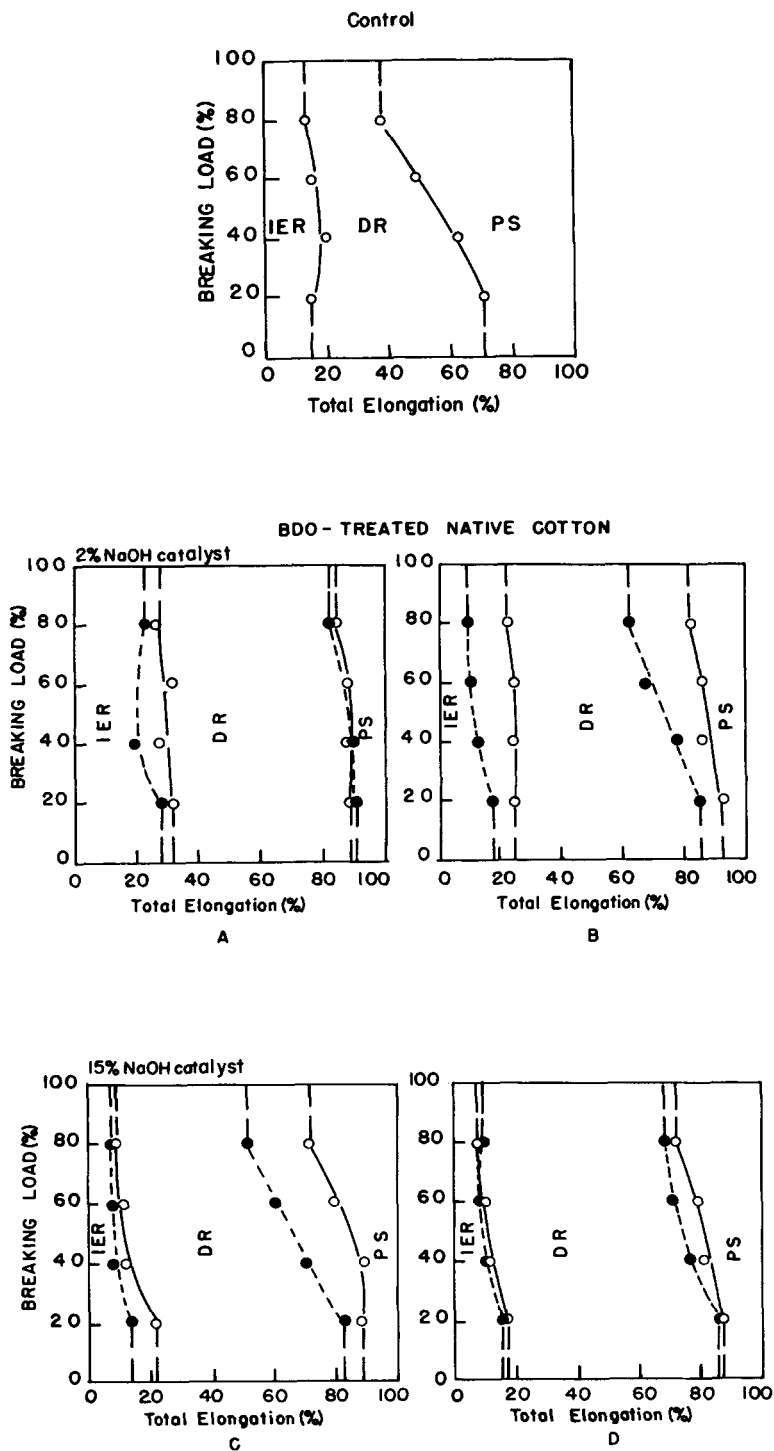


Fig. 7. Effects of BDO reaction and of postmercerization of BDO-treated products (A&C = low add-ons; B&D = high add-ons) upon tensile recovery of native cotton: (O) BDO-treated; (●) postmercerized BDO-treated cotton. IER = Immediate elastic recovery; DR = delayed recovery; PS = permanent set.

stress is released, was tested by the method of Susich and Backer.⁷ Recovery profiles for each control obtained from stress-strain curves are shown in quadratic graphs of Figure 6. Profiles have three components: (1) immediate elastic recovery (IER) or that elongation recovered immediately upon remov-

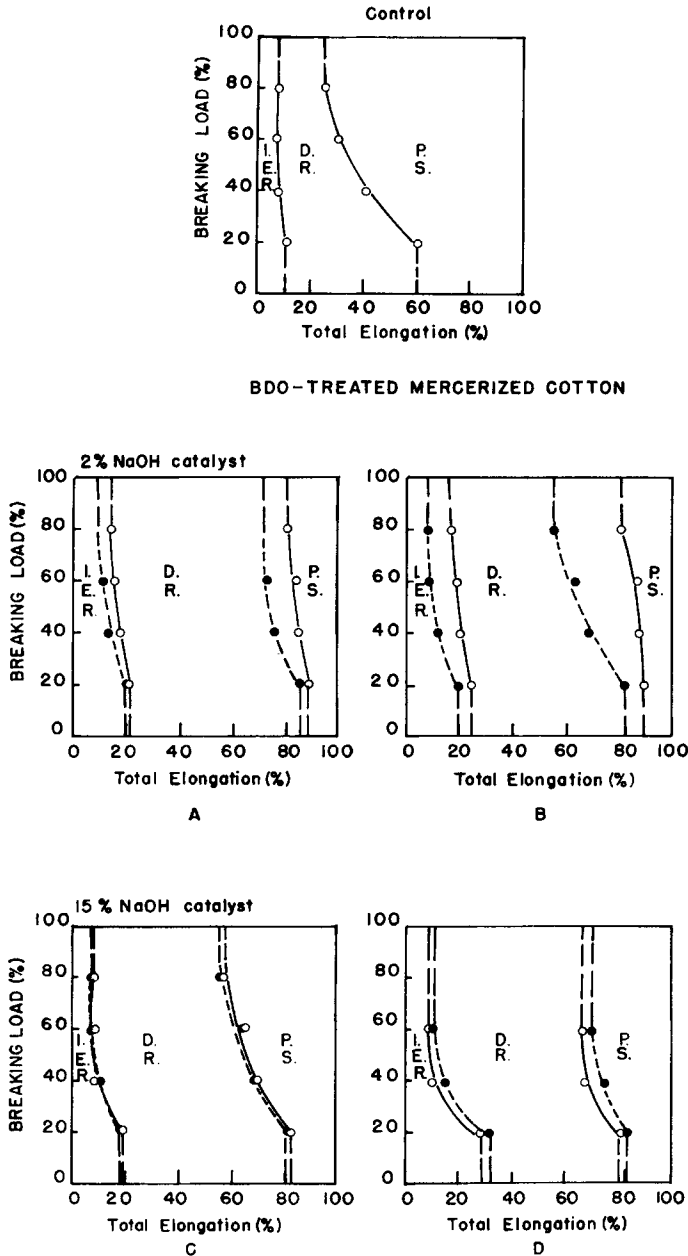


Fig. 8. Effects of BDO reaction and of postmercerization of BDO-treated products (A&C = low add-ons; B&D = high add-ons) upon tensile recovery of conventionally mercerized cotton: (O) BDO-treated; (●) postmercerized BDO-treated cotton. IER = Immediate elastic recovery; DR = delayed recovery; PS = permanent set.

al of stress, (2) delayed recovery (DR) or that which is recovered after a long-
 er time, and (3) permanent set (PS) or that elongation which is never recov-
 ered. In general, CM cotton had the least IER and the greatest PS. NH_3 -
 treated fabrics had the least PS in the warp direction and were equivalent to
 native cotton in the fill direction. However, recovery areas of the profiles indicate
 that NH_3 -treated cottons differed from native cotton in ability to re-

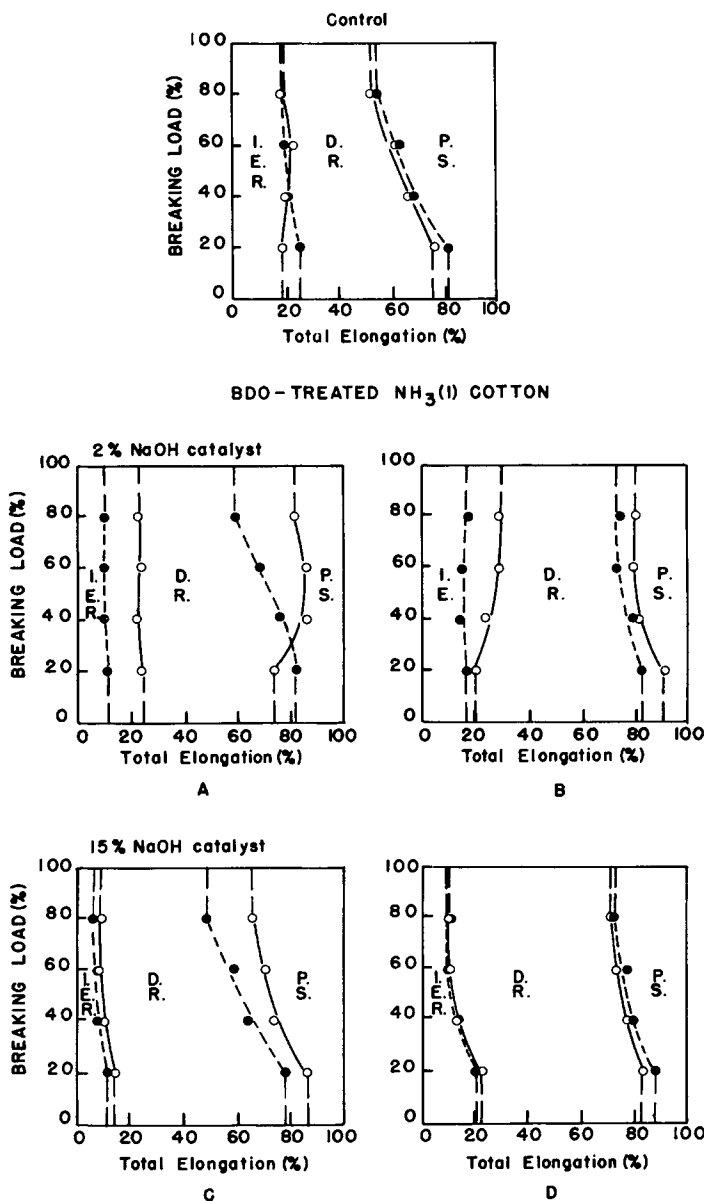


Fig. 9. Effects of BDO reaction and of postmercerization of BDO-treated products (A&C = low add-ons; B&D = high add-ons) upon tensile recovery of cotton pretreated with liquid NH_3 to yield cellulose I: (O) BDO-treated; (●) postmercerized BDO-treated cotton. IER = Immediate elastic recovery; DR = delayed recovery; PS = permanent set.

cover from stress over a long period of time, i.e., DR or "primary creep." Profiles of IER were nearly identical for NH₃-treated and native cotton controls.

Effects of BDO reaction and of postmercerization of these products upon

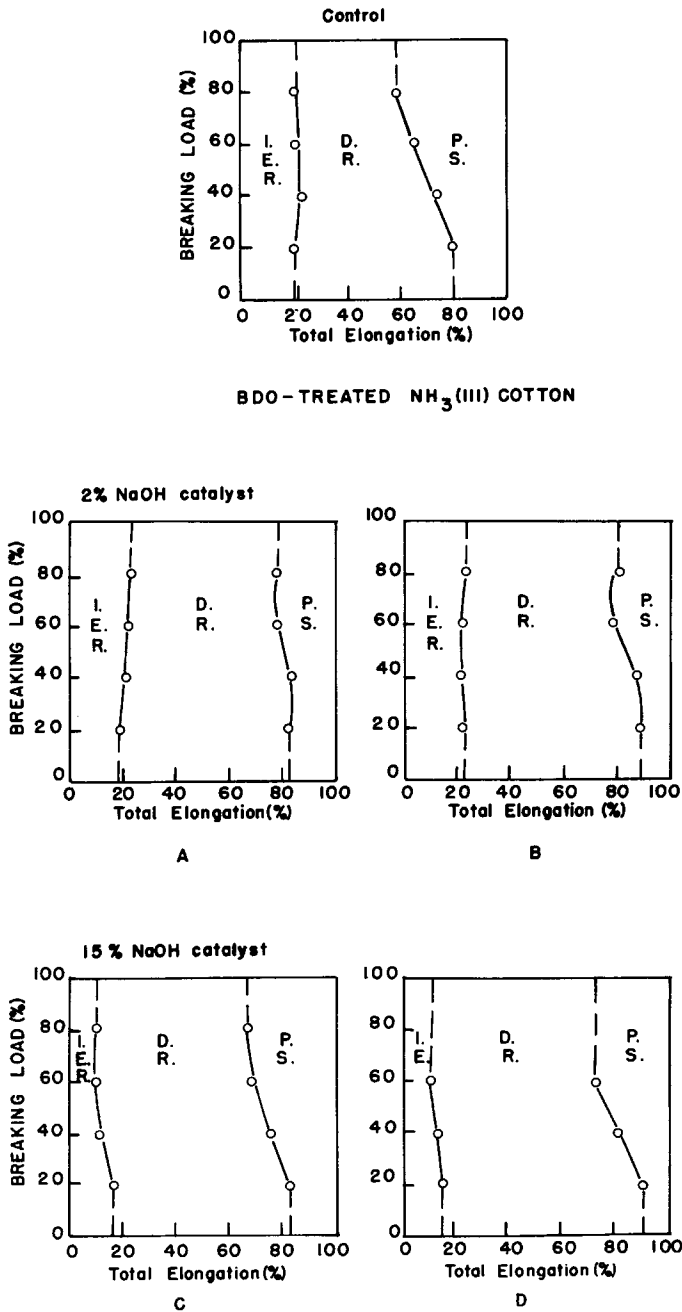


Fig. 10. Effects of BDO reaction upon tensile recovery of cotton pretreated with liquid NH₃ to yield cellulose III (A&C = low add-ons; B&D = high add-ons): (O) BDO treated. IER = Immediate elastic recovery; DR = delayed recovery; PS = permanent set.

tensile recovery of each control are demonstrated by recovery profiles of changes occurring in the warp direction (Figs. 7-10). Generally, effects in the filling direction were similar. BDO reaction significantly reduced PS and improved overall tensile recovery of each control, the increase being due primarily to a larger DR. Generally, PS was less in BDO products (low or high add-on) obtained with 2% NaOH than with 15% NaOH catalyst. Although control cottons had somewhat different recovery profiles, recovery behavior after BDO reaction was quite similar for comparable reaction products prepared with 2% NaOH as catalyst. With 15% NaOH, only products having a high BDO add-on had similar recovery profiles; at low add-ons, PS tended to be less for BDO products from native and NH_3 -treated cottons than for those from CM cotton. Postmercerization generally increased PS and decreased IER of all BDO-reaction products prepared with 2% NaOH as catalyst, and changes were greater in the warp than fill direction. With 15% NaOH, postmercerization effects depended upon BDO add-on and upon the control from which products were prepared. At low add-ons, for postmercerized BDO products from native and NH_3 (I) cottons, PS increased due primarily to a decrease in DR; but recovery profiles of comparable products from the CM control were not affected. At high add-ons and 15% NaOH catalysis, only products from native cotton were affected by postmercerization, which increased PS and made recovery profiles more like those of products from similarly treated CM cotton.

SUMMARY AND CONCLUSIONS

Textile properties of cottons treated with liquid ammonia or with 23% NaOH compare favorably after BDO reaction. Initially, tensile properties of the CM cotton greatly exceeded those of native and NH_3 -treated cottons. BDO reaction enhanced wrinkle recovery properties, but, like most crosslinking reactions, reduced tensile properties so that the initial tensile advantage held by the CM control was nullified. The tensile advantage was nullified because of (1) greater relative strength losses by CM cotton and (2) partial restoration of ultimate elongation and energies of rupture accompanying postmercerization of BDO-treated native and NH_3 (I) cottons. Tear strengths and resistance to flex abrasion of CM and NH_3 -treated cottons were comparable before and after BDO reaction. However, the twofold increase in flex abrasion achieved by initial mercerizations, CM and NH_3 , of native cottons was virtually destroyed by BDO reaction. High dry and high wet wrinkle recoveries were achieved only when 2% NaOH catalyzed the BDO reaction; under these conditions, BDO-treated NH_3 (I) cottons had the greatest dry and wet wrinkle recoveries. Recovery profiles showed differences in ability of CM and NH_3 -mercerized cottons to recover from deformation when the deforming stress was relaxed. CM cotton had the least immediate elastic recovery (IER) and the greatest permanent set (PS) while the NH_3 -treated cotton had the least PS and the greatest overall recovery. NH_3 -treated and native cottons had almost identical IER components; but delayed recoveries (DR) differed such that NH_3 -treated cottons had the least PS. BDO reaction reduced PS of all controls and increased overall tensile recovery primarily by enlarging the DR component. Products obtained with 2% NaOH catal-

ysis had the least PS. It is noteworthy also that only with 2% base catalysis were high dry and high wet wrinkle recoveries achieved. Recovery profiles of all BDO-treated fabrics were similar; but at low BDO add-ons, PS tended to be lower for products from native and NH_3 -treated cottons than for comparable CM cottons.

The strength of the base catalyst is a primary factor in the response of BDO-reaction products to postmercerization with 23% NaOH. Generally, with 2% NaOH catalysis, postmercerization affected textile properties of all reaction products, though effects were slight for products from CM cotton. With 15% NaOH catalysis, only textile properties of BDO-treated cottons having the cellulose I crystalline lattice were further modified. Postmercerization adversely affected recovery behavior of all BDO-treated products regardless of crystalline structure. Nevertheless, wrinkle and tensile recoveries of postmercerized products from NH_3 (I) and CM cottons were equivalent.

The effect of postmercerization upon other textile properties seemed structure related. Fabric properties of BDO-treated cottons retaining the cellulose I lattice were partially restored to those of their respective controls by postmercerization, but little or no change was noted in properties of corresponding products from CM cotton. Thus, final properties of BDO products from NH_3 (I) cotton equaled and even exceeded those of comparable CM reaction products.

The authors thank Dr. Timothy A. Calamari and Sidney P. Schreiber for preparation of ammonia-treated celulosés, and Judith Bogatz and Annie B. Cooper for textile testing.

References

1. H. Z. Jung, R. J. Berni, R. R. Benerito, and J. H. Carra, *Text. Res. J.*, **45**, 681 (1975).
2. H. M. Ziifle, R. J. Berni, A. M. Cannizzaro, and R. R. Benerito, *Text. Res. J.*, **36**, 389 (1966).
3. H. M. Ziifle, R. R. Benerito, R. J. Berni, and A. M. Cannizzaro, *Text. Res. J.*, **38**, 1101 (1968).
4. R. R. Benerito, R. J. Berni, J. B. McKelvey, and B. G. Burgis, *J. Polym. Sci. A*, **1**, 3407 (1963).
5. American Society for Testing Materials, Philadelphia, Pa., ASTM Specification (a) D1019-64; (b) D1682-64; (c) D1424-63; (d) D1175-71; (e) D1295-67.
6. R. A. Fujimoto, R. M. Reinhardt, and J. D. Reid, *Amer. Dyestuff Repr.*, **52**, 329 (1963).
7. G. Susich and S. Backer, *Text. Res. J.*, **21**, 482 (1951).

Received July 30, 1975

Revised September 17, 1975