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ROT-RESISTANCE OF COTTON/NYLON BLENDS

by

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FOREWORD

This report is an evaluation of the microbiological resistance of various cotton/nylon blends, treated and non-treated. The study was conducted to determine the rot-resistance of the blends and the effectiveness of treatment with various recognized cotton preservatives.

The authors are indebted to Mr. W. Norbert Berard of the U. S. Department of Agriculture for his guidance in the treatment of cotton/nylon blends by the formic acid colloid of methylolmelamine. Likewise, Mr. Guy D. Moulton of Ciba Chemical and Dye Company is to be thanked for his assistance in the preparation of the blends by the "Arigal" process.

The work reported herein was accomplished under project number 1J062110A031.

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ABSTRACT

Cotton/nylon blends differing in the proportion of cotton to nylon, the degree of interfiber intimacy and the geometric distribution of cotton to nylon were evaluated for rot-resistance in the soil burial test. Additional soil burial data were obtained from the same blends following treatment with either copper 8-quinolinolate or methylolmelamine resin. All materials were subject to 100 hours of full cycle exposure in a twin arc weatherometer.

The cotton fibers in the untreated blends were susceptible to damage by microorganisms which ultimately impaired the functional values of all such blends tested. The treated blends, however, were effectively protected by the cotton preservatives employed. The treatment levels employed, though sufficient for microbiological protection, provided essentially no protection from the effects of U-V radiation.

INTRODUCTION

There has been considerable military interest in the development and utilization of cotton/nylon blends for textiles (7,8,10). This has resulted in the preparation and evaluation of numerous fabric blends differing in such parameters as the proportion of cotton to nylon, the degree of interfiber intimacy and the geometric distribution of cotton and nylon. The mechanical properties of these blends have been well characterized. However, little information is available regarding rot-resistance of the blends or the applicability of treatment with recognized cotton preservatives.

This study is [illegible] valuation of the mildew-resistance of various treated and non-[illegible] blends primarily drawn from procurement stocks. The trea[illegible]nts applied included both a conventional fungicide, copper 8-quinolinolate (Cu-8) which has been widely used for many years as an add-on fungicide for the protection of military cotton goods, and methylolmelamine resin, a relatively newer rot-resistant treatment.

The superior weather- and rot-resistance of cotton duck treated with the formic acid colloid of methylolmelamine was reported by Kempton et al. (3). A later report compared several other competitive methods for applying the resin (4).

This report contains comparative soil burial and weatherometer data for cotton/nylon blends before and after treatment with copper 8-quinolinolate and methylolmelamine resin by two of the processes previously evaluated. The applicability of these cotton preservatives as weather- and rot-resistant finishes for cotton/nylon blends is discussed.

MATERIALS AND METHODS

Fabrics

Fabrics were selected to represent the three possible levels at which the cotton and nylon can be blended, i.e., intimate intermix at the fiber level, the plying of cotton yarn with continuous filament nylon yarn to achieve a yarn blend, and the weaving of cotton yarns and nylon yarns into a fabric blend.

Table I lists the fabrics tested Several of the fabrics were furnished as treated blends drawn from procurement stock. The others were treated under the supervision of personnel involved in the respective processes. The application of methylolmelamine as a colloid of

TABLE I

FABRICS TESTED

Base Fabric Data			Treatment Data		
Source Designation	Source	Blend Level	Treatments Applied	Concentration % by Analysis	Place of Treatment
Cloth, cotton warp/nylon filling oxford, 5-oz OG-107	C&OML[1]	fabric	None	---	---
Cloth, 50% nylon/50% cotton poplin 5-oz loomstate	DSCD[2]	yarn	formic acid colloid "Arigal"	6.5 3.0	NLABS Ciba Corp.
Cloth, 50% nylon/50% cotton poplin 6-oz OG-107	C&OML	fiber	formic acid colloid "Arigal"	5.7 9.2	NLABS Northern Dyeing Corp.
Cloth, 50% nylon/50% cotton duck 14.5-oz OG-107	C&OML	fiber	copper 8-quinolinolate	0.26	Shawmut Mills

1. Clothing and Organic Materials Laboratory, U. S. Army Natick Laboratories.
2. Directorate of Stores and Clothing Development, Colchester, Essex, England.

formic acid was achieved by the conventional pad, dry and cure technique common to resin finishes. Details of the process are described by Berard et al. (1,2). The "Arigal" treatment for application of methylolmelamine is a wet-fixation process patented by Ruperti (6).

The nominal resin concentration aimed for was 6% based on total fabric weight. Since the fabrics to be treated were 50/50 cotton/nylon blends and resin treatment is substantive to the cotton, only half the normal 12% add-on for optimum rot-resistance of all-cotton fabrics was required. However, two of the fabrics tested were treated to contain significantly higher and lower resin add-on.

Test Methods

All samples to be tested were conditioned at 70 $\pm 2^{\circ}F$ and 65 $\pm 2\%$ RH for at least 24 hours. Therefore, the results of chemical analyses contain a small but constant error due to moisture content.

Weatherometer and soil burial testing were conducted on 1 x 6 inch ravelled warp strips in accordance with methods 5670 and 5762 of Federal Specification CCC-T-191b (9).

Breaking strengths were measured on an Instron tensile tester and tearing strengths on an Elmendorf tear test machine according to methods 5104.1 and 5132, respectively, of Federal Specification CCC-T-191b.

Nitrogen content of resin and resin-treated fabrics was determined by use of a Thomas-ASTM Microkjeldahl apparatus. The nitrogen content of the resin was used to calculate the resin content of the fabrics. Copper 8-quinolinolate was assayed by the spectrophotometric method originally described by Rose et al. (5).

RESULTS AND DISCUSSION

The rot-resistance of a textile fabric can generally be determined from its tensile strength retention following soil burial. However, fiber blends may present a special problem in terms of localized differences in biodegradability. In cotton/nylon blends there is a marked difference in the susceptibility of the two fibers to microbiological attack. Cotton fibers degrade readily, but nylon is resistant. Since tensile strength data are a measure of fabric and not fiber strength, such data will also be affected by the physical parameters characterizing the blend such as the degree of inter-fiber intimacy and the geometric distribution of cotton and nylon. Therefore, although the rot-resistance of a cotton/nylon blend is solely dependent on the ratio of biodegradable cotton fibers to resistant nylon fibers, tensile strength measurements reflect the physical arrangement within as well as the composition of the fabric blend.

Table II and Figure 1 demonstrate the rot-resistance of cotton/nylon fabrics representative of the various blending modes. These fabrics were not treated for protection from microbiological degradation. Tensile strength retention during soil burial was related to the manner or degree of cotton/nylon blending. Tensile strength losses were due to biodegradation of the cotton, and the residual strength to the unattacked nylon. This is why the 5-oz cotton warp/nylon fill fabric lost 87% strength following only 14 days of soil burial when the tensile breaks were performed as a warp test. The nylon content calculated from nitrogen measurements indicated this fabric contained 78/22 cotton/nylon. Yarn weighings indicated the distribution in the warp and fill directions was 78 and 22%, respectively. Increased cotton content alone would not have accounted for the total loss of strength not observed in any of the other test fabrics. These results demonstrate the effect a high degree of fiber orientation can have on the residual tensile strength. In contrast, the 5-oz 50/50 cotton/nylon loomstate poplin comparable in weight and initial strength lost only 53% of its strength following 56 days of soil burial. The 5-oz loomstate poplin, which was prepared by plying cotton yarn with continuous filament nylon yarn, represented blending at the yarn level. The better performance of this fabric was basically due to orientation of nylon in both the warp and fill directions. However, the fabric admittedly did contain a significantly higher nylon content than the cotton warp/nylon fill fabric. The 6-oz 50/50 cotton/nylon OG-dyed poplin represented intimate intermix at the fiber level. Although the loomstate poplin was initially 37% stronger than the dyed poplin, following 28 days of soil burial the loomstate poplin was actually 7% weaker than the dyed poplin soil buried for 30 days. The superior performance of the intimate blend was probably due to greater frictional forces resulting from uniform distribution of nylon fibers throughout all the yarns. The 14.5-oz OG-107 50/50 cotton/nylon OG-dyed duck also represented intimate intermix at the fiber level but in the form of a substantially heavier fabric. The 14.5-oz duck did not lose strength as readily as the 6-oz poplin within the first 60 days of soil burial. However, both fabrics demonstrated comparable tensile strength loss in the 30% range after 120 days.

Despite measurable differences in tensile strength losses, all four fabrics had, in effect, been decimated by microbiological attack and no longer could satisfy functional requirements. Two cotton preservatives, copper 8-quinolinolate and methylolmelamine resin, were applied to see if tensile strength losses resulting from biodegradation of the cotton could be reduced.

TABLE II

ROT-RESISTANCE OF UNTREATED COTTON/NYLON RICS BLENDED AT THE FIBER, YARN AND FABRIC LE..LS

Soil Burial In days	Cotton blended at fabric level, 78% cotton warp/22% nylon fill, oxford 5-oz OG-107		Cloth blended at yarn level, 50% nylon/50% cotton poplin 5-oz loomstate		Cloth blended at fiber level, 50% nylon/50% cotton poplin 6-oz OG-107		Cloth blended at fiber level, 50% nylon/50% cotton duck 14.5-oz OG-107	
	Mean Break. S, lb	% loss	Mean Break. S, lb	% loss	Mean Break. S, lb	% loss	Mean Break. S, lb	% loss
0	171	0	163	0	119	0	281	0
14	22	87	80	51	-	-	-	-
30	-[1]	-[1]	80[2]	51[2]	86	28	270	4
42	-	-	78	52	-	-	-	-
60	-	-	77[3]	53[3]	85	29	238	15
90	-	-	-	-	85	29	215	23
120	-	-	-	-	83	30	195	31

1. Sample destroyed during soil burial prior to the 28 day harvest.
2. 28 days of soil burial.
3. 56 days of soil burial.

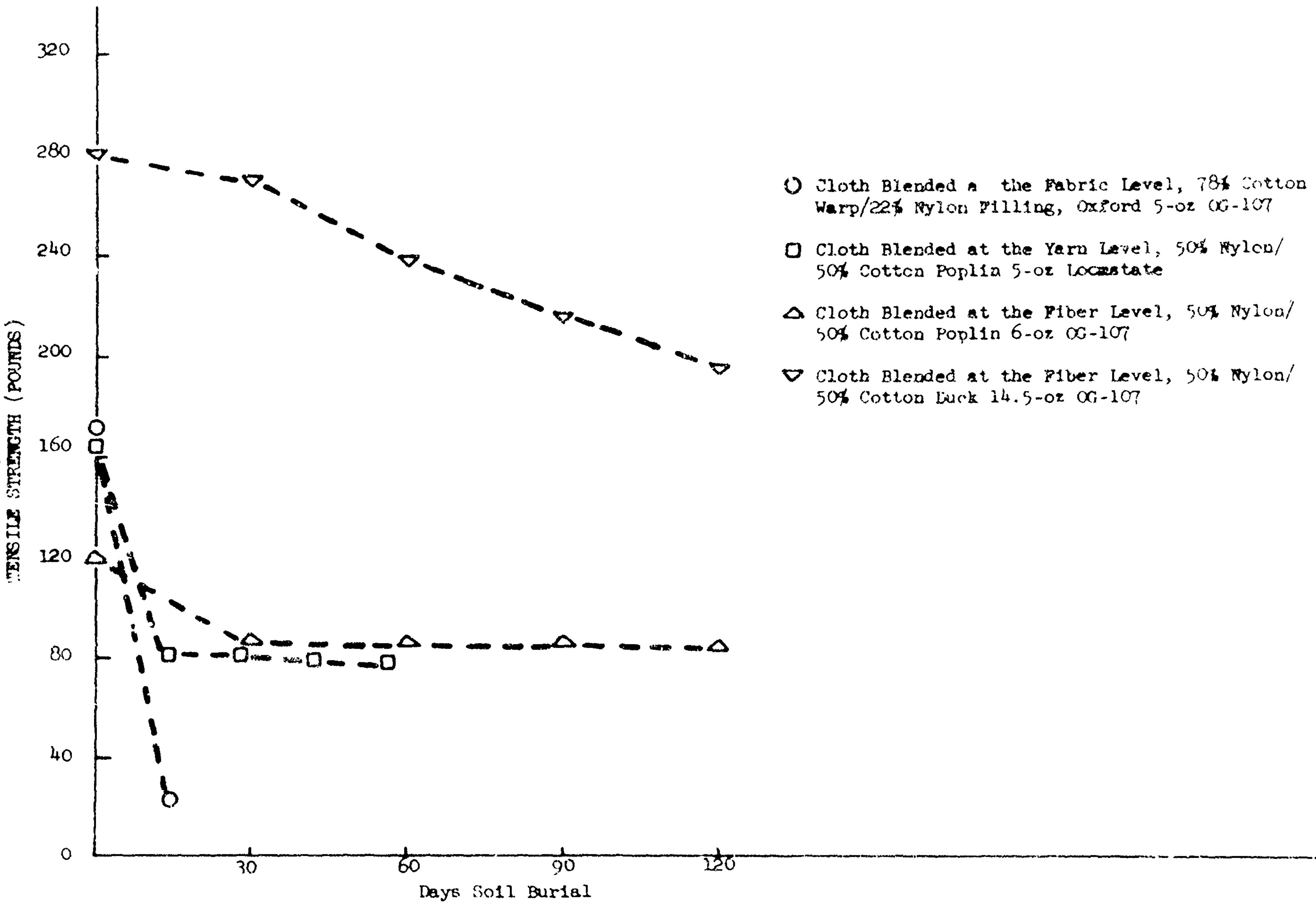

Figure 1. Rot-Resistance of Untreated Cotton/Nylon Fabrics Blended at the Fiber, Yarn and Fabric Levels.

Table III and Figure 2 contain the soil burial data following resin treatment of the fabric which had been woven from cotton yarn plied with continuous filament nylon yarn. Comparable data for the untreated fabric are included for comparison. The Arigal treated fabric contained only 3.0% resin calculated from the nitrogen content, but microbiological deterioration of the cotton was nevertheless reduced. The fabric treated with the formic acid colloid of methylolmelamine did not perform as well as expected despite 6.5% resin which was sufficient to protect the cotton. It was therefore not completely representative of the better "dry-cure" treatments previously evaluated. Both resin treatments caused a drastic tensile strength loss thereby impairing the mechanical properties of the blend. The 29% loss in strength caused by the Arigal treatment was entirely unexpected since it does not typically cause any tensile strength loss even at the 10-12% resin add-on level. However, a 31% tensile strength loss would be typical for fabric containing 10-12% resin after treatment by the "formic acid colloid" process

The rot-resistance data derived from the resin-treated 50% nylon/ 50% cotton poplin 6-oz OG-107 intimate blend ("Nyco") are contained in Table IV and Figure 3. Again comparable data for the untreated fabric are included for comparison. Both wet and dry-cure resin treatments were highly effective, and there was negligible tensile strength loss due to microbiological degradation during 4 months of soil burial. The base fabric lost negligible tensile strength as a result of either resin treatment. The Arigal "wet-cure" treatment had no effect on the breaking strength despite the 9.2% resin content calculated from nitrogen measurements, but the "dry-cure" treatment at the 5.7% level did cause a 6% loss in strength.

Tear strength data for the blended fabrics which were resin-treated are listed in Table V. There was considerable tear strength loss resulting from treatment with 6% or more resin add-on. However, the data from the plied yarn blend containing 3.0% Arigal resin indicated that tear strength loss might be minimized at lower add-on levels.

Table VI and Figure 4 contain the soil burial data obtained from the nylon/cotton duck 14.5-oz OG-107 intimate blend ("Nyco") treated with copper 8-quinolinolate. In this case good results were obtained with an add-on fungicide. This fabric contained only 0.26% copper-8 based on total fabric weight when analyzed by Rose's Method for copper 8-quinolinolate. However, the effective concentration in the cotton may be significantly higher because cotton fibers are more absorbent than nylon fibers.

Tensile strength data for the untreated and treated blends before and after 100 hours of weatherometer exposure are listed in Table VII.

TABLE III

ROT-RESISTANCE OF CLOTH BLENDED AT THE YARN LEVEL,
50% NYLON/50% COTTON POPLIN 5-0% LOOMSTATE
BEFORE AND AFTER TREATMENT BY TWO PROCESSES FOR APPLICATION OF METHYLOLMELAMINE RESIN

Soil Burial in days	Untreated Control		"Arigal" treatment, 3.0% resin by analysis		"Formic acid colloid" treatment, 6.5% resin by analysis	
	mean breaking strength in lbs.	% loss	mean breaking strength in lbs.	% loss	mean breaking strength in lbs.	% loss
0	163	0	115	29[3]	112	31[3]
14	80	51	-	-	-	-
30	80[1]	51[1]	101	12	83	26
42	78	52	-	-	-	-
60	77[2]	53[2]	93	19	74	34
90	-		76	34	65	42
120	-		49	57	62	45

1. 28 days of soil burial.
2. 56 days of soil burial.
3. % loss based on untreated control.

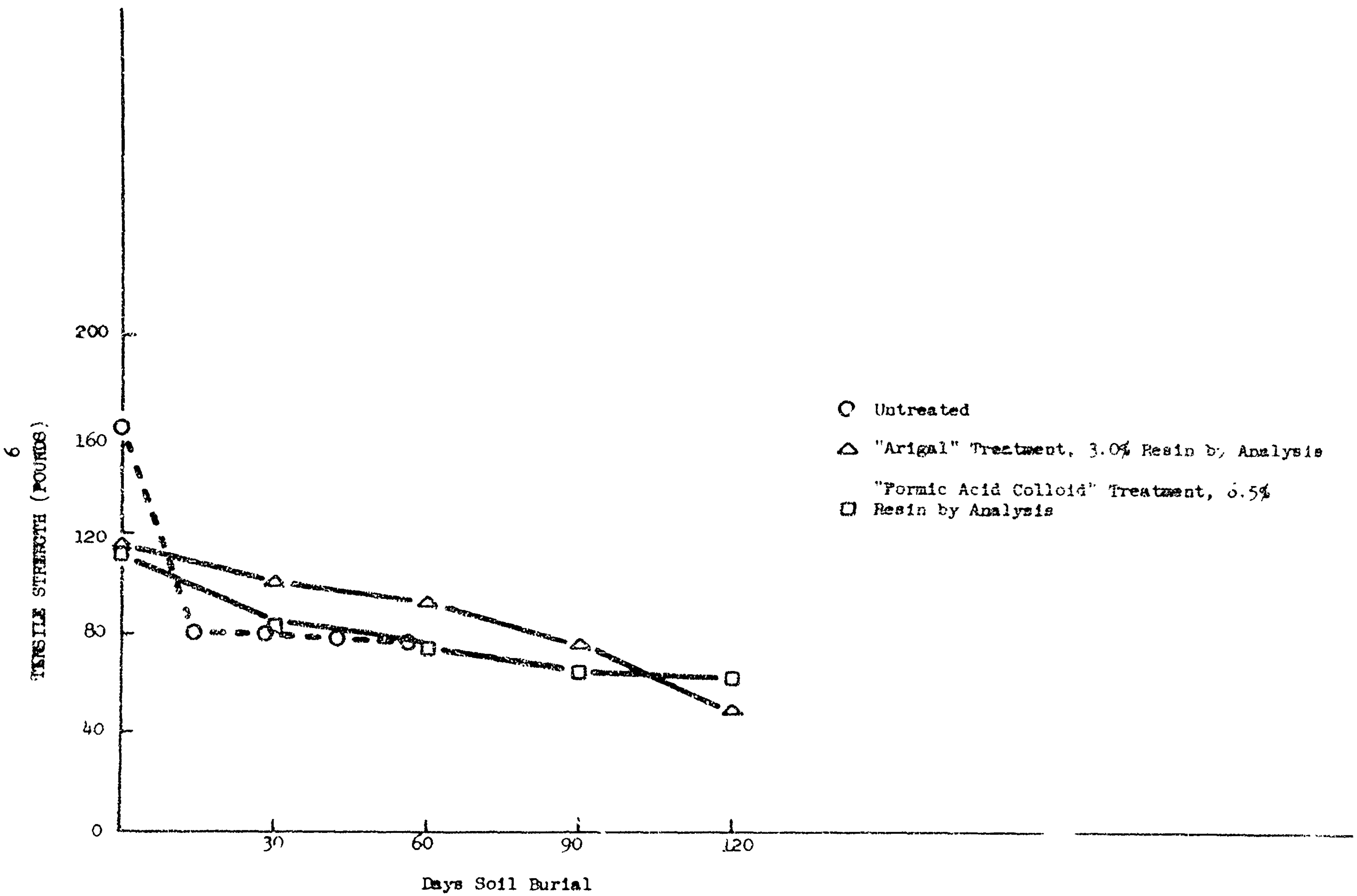

Figure 2. Rot-Resistance of Cloth Blended at the Yarn Level, 50% Nylon/50% Cotton Poplin 5-oz Loomstate before and after treatment by two processes for application of Methylolmelamine Resin.

TABLE IV

ROT-RESISTANCE OF CLOTH BLENDED AT THE FIBER LEVEL,
50% NYLON/50% COTTON POPLIN 6-OZ OG-107
BEFORE AND AFTER TREATMENT BY TWO PROCESSES FOR APPLICATION OF METHYLOLMELAMINE RESIN

Soil burial in days	Untreated Control		"Arigal" treatment, 9.2% resin by analysis		"Formic acid colloid" treatment, 5.7% resin by analysis	
	mean breaking strength in lbs.	% loss	mean breaking strength in lbs.	% loss	mean breaking strength in lbs.	% loss
0	119	0	120	1[1]	112	6[2]
30	86	28	118	2	111	1
60	85	29	114	5	102	9
90	85	29	110	8	102	9
120	83	30	106	12	97	13

1. % gain based on untreated control.
2. % loss based on untreated control.

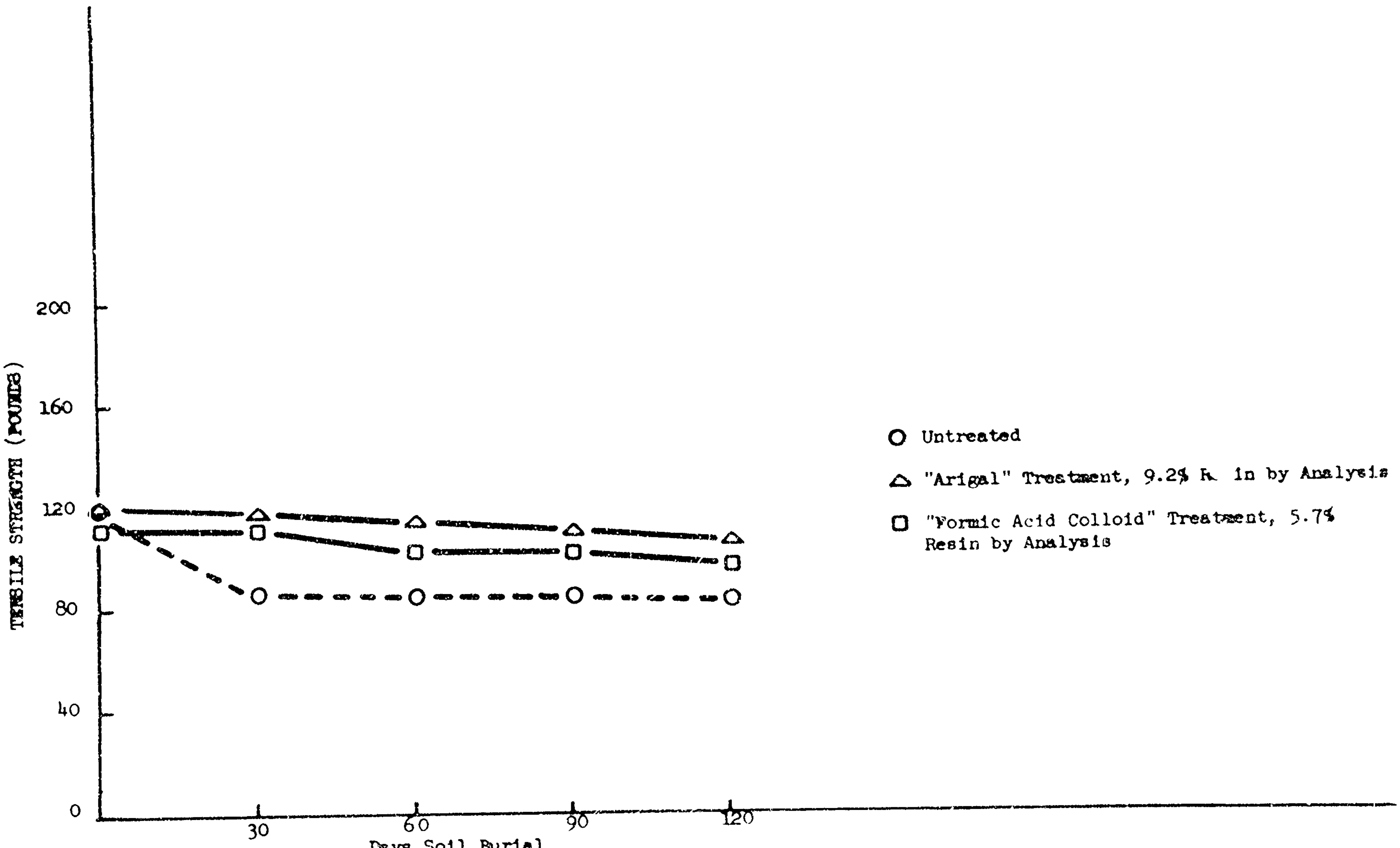

Figure 3. Rot-Resistance of Cloth Blended at the Fiber Level, 50% Nylon/50% Cotton Poplin 6-oz Qm-107 before and after Treatment by Two Processes for Application of Methylolmelamine Resin.

TABLE V

TEAR TEST RESULTS FROM COTTON/NYLON BLENDS
BEFORE AND AFTER TREATMENT WITH METHYLOLMELAMINE RESIN BY TWO PROCESSES

Fabric Description	Mean tear strength in grams	% tear strength loss after treatment
Cloth, blended at the yarn level, 50% nylon/50% cotton poplin 5-oz loomstate, untreated	2707	----
Same, Arigal treatment, 3.0% resin by analysis	2368	12.5
Same, formic acid colloid treatment, 6.5% resin by analysis	2134	21.2
Cloth, blended at the fiber level, 50% nylon/50% cotton poplin 6-oz OG-107, untreated	2591	----
Same, Arigal treatment, 9.2% resin by analysis	1878	27.5
Same, formic acid colloid treatment, 5.7% resin by analysis	1862	28.1

TABLE VI

ROT-RESISTANCE OF CLOTH BLENDED AT THE FIBER LEVEL,
50% NYLON/50% COTTON DUCK 14.5-OZ OG-107
BEFORE AND AFTER TREATMENT WITH COPPER 8-QUINOLINOLATE

Soil burial in days	Untreated Control		Copper 8-quinolinolate treated, 0.26% by analysis	
	mean breaking strength in lbs.	% loss	mean breaking strength in lbs.	% loss
0	281	0	284	1[1]
30	270	4	282	1
60	238	15	279	2
90	215	23	270	5
120	195	31	270	5

1. % gain based on untreated control.

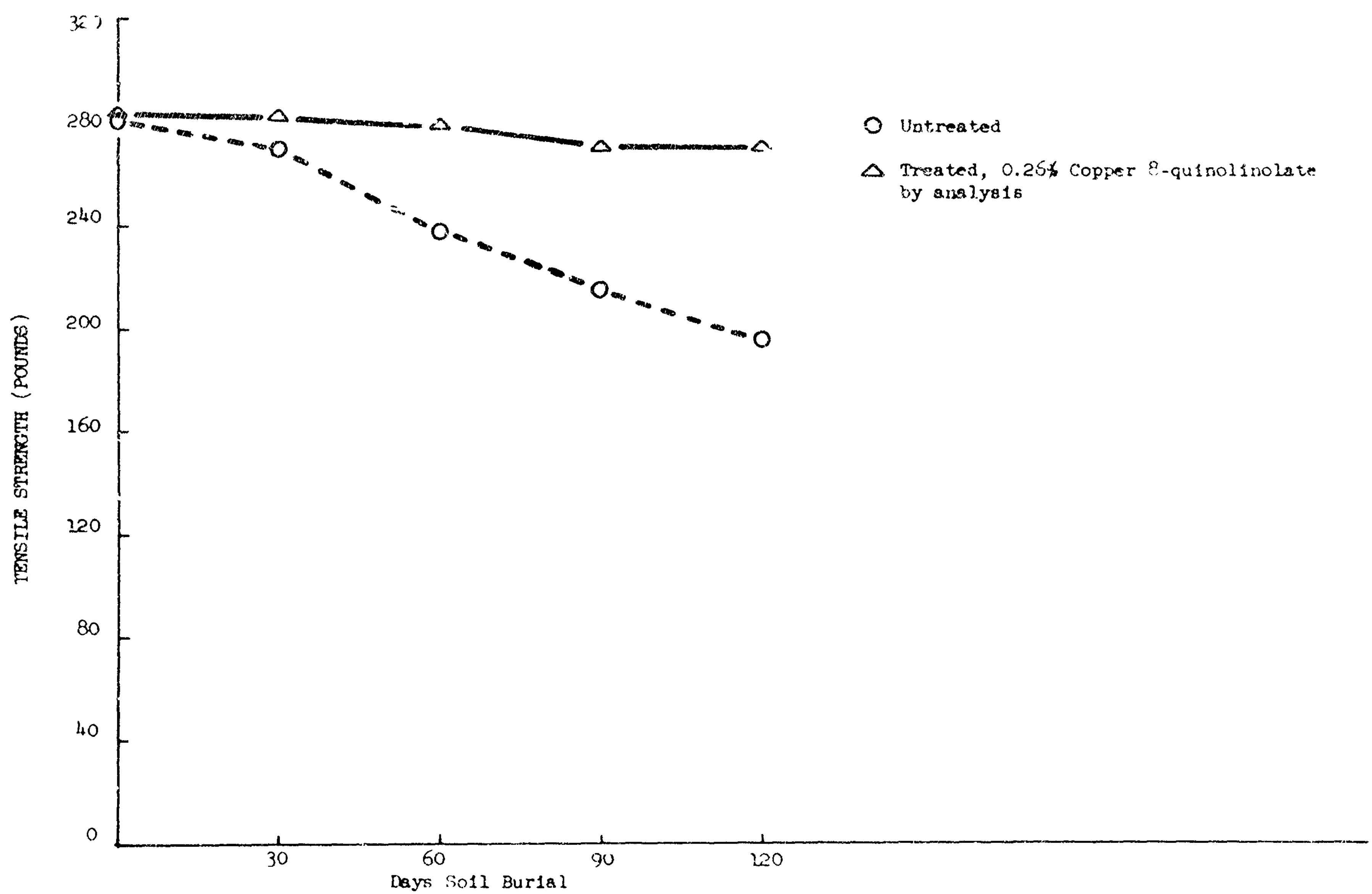

Figure 4. Rot-Resistance of Cloth Blended at the Fiber Level, 50% Nylon/50% Cotton Duck 1..5-oz OG-107 before and after Treatment with Copper 8-quinolinolate.

TABLE VII

TENSILE STRENGTH RESULTS FROM UNTREATED AND TREATED COTTON/NYLON BLENDS BEFORE AND AFTER 100 HOURS OF WEATHEROMETER EXPOSURE

Fabric Description	Tensile strength in lbs. before weath. exposure	Tensile strength in lbs. after weath. exposure	% loss
Cloth blended at the yarn level, 50% nylon/50 % cotton poplin 5-oz loomstate, untreated	163	63	61
Same, "Arigal" treatment, 3.0% resin by analysis	115	55	52
Same, "formic acid colloid" treatment, 6.5% resin by analysis	112	57	49
Cloth blended at the fiber level, 50% nylon/50% cotton poplin 6-oz OG-107, untreated	119	56	53
Same, "Arigal" treatment, 9.2% resin by analysis	120	116	3
Same, "formic acid colloid" treatment, 5.7% resin by analysis	112	74	34
Cloth blended at the fiber level, 50% nylon/50% cotton duck 14.5-oz OG-107, untreated	281	190	32
Same, 0.26% copper 8-quinolinolate by analysis	284	202	29

Two of the base fabrics were dyed and the third was in "loomstate". The drastic tensile strength losses evident in the untreated fabrics were primarily due to U-V degradation of the nylon. The heavy 14.5-oz duck lost only 32% of its strength in contrast to the 53 and 61% losses occurring in the 6- and 5- oz poplin fabrics, respectively. There was evidence that low treatment levels offered some protection from irradiation. The Arigal treated 6-oz intimate blend poplin which performed excellently contained 9.2% resin. Although Kjeldahl analysis indicated that the resin is substantive to the cotton, these data suggest that higher treatment levels may afford the nylon significant protection from U-V breakdown.

CONCLUSIONS

The cotton fibers in the untreated blends were susceptible to damage by microorganisms which ultimately impaired the functional values of all such blends tested. The tensile strength retention of the untreated fabrics during soil burial was found to be related to the mode of cotton/nylon blending. The treated blends, however, were effectively protected by the cotton preservatives employed.

Copper 8-quinolinolate and methylolmelamine resin treatment by either "wet" or "dry" cure processes were effective mildew-inhibitors at approximately half the add-on normally required for all-cotton fabrics. However, this lower concentration did not significantly reduce the damage to the mechanical properties of the blend caused by the resin. Also, at this concentration there was essentially no protection from the effects of U-V radiation. There was evidence though that a higher level of methylolmelamine resin, approximately 10%, might significantly reduce actinic degradation of the nylon.

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13. ABSTRACT

Cotton/nylon blends differing in the proportion of cotton to nylon, the degree of interfiber intimacy and the geometric distribution of cotton to nylon were evaluated for rot-resistance in the soil burial test. Additional soil burial data were obtained from the same blends following treatment with either copper 8-quinolinolate or methylolmelamine resin. All materials were subjected to 100 hours of full cycle exposure in a twin arc weatherometer.

The cotton fibers in the untreated blends were susceptible to damage by microorganisms which ultimately impaired the functional values of all such blends tested. The treated blends, however, were effectively protected by the cotton preservatives employed. The treatment levels employed, though sufficient for microbiological protection, provided essentially no protection from the effects of U-V radiation.

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	ROLE	WT	ROLE	WT	ROLE	WT
Biodeterioration	8		9		6	
Cotton	9		9		7	
Nylon	9		9		7	
Cotton	9		9		7	
Blends	9		9		7	
Fabrics	9		9		7	
Tests			8			
Rotting	8		8		6	
Rotproofing	8					
Resistance	8					
Ultraviolet radiation	8				6	