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HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND
Quartermaster Research & Engineering Center, US Army
Natick, Massachusetts

TEXTILE, CLOTHING & FOOTWEAR DIVISION
3 Textile Functional Finishes Laboratory Report No. 173

FLAMEPROOFING OF NYLON FABRICS

by

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Project Reference:
7-12-01-002

September 1957

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I. INTRODUCTION

This report summarizes work that has been done to develop a finish capable of rendering nylon fabrics flame and drip-proof. If such a finish were available, the high strength and low weight characteristics of nylon could be used to advantage in lightweight tentage.

The flaming and dripping of molten nylon when the fabric is ignited is undesirable. The flaming melt presents a dual hazard: it may propagate flaming as it drips onto flammable material and it can cause serious burns to personnel both from the flaming and from the fact that the molten nylon adheres to the skin and releases heat as it cools.

A preliminary investigation to remedy this condition was initiated when it was noted that neoprene coated nylon, when ignited, burned but did not drip after combustion and left a crisp paper-like char.

II. PURPOSE

Treatment of nylon fabric with existing commercial flame retardants eliminates flaming but does not prevent melting and dripping when in contact with a flame. Methods of rendering nylon fabric flame resistant without producing a melt are investigated.

III. DISCUSSION AND RESULTS

As mentioned above it was noted that neoprene coated nylon fabric, when exposed to a flame, burned but left a crisp paper-like char and did not drip. Untreated nylon left a hard, brittle char and the melt dropped off.

A. Attempts to flame-proof neoprene-coated nylon and retain its char. Attempts to render the fabric flame resistant as well as drip-proof were made by adding a series of chemicals to the neoprene emulsion before coating Various chemicals known to exhibit flame or glow proof characteristics were selected and are listed as follows:

ammonium borate
ammonium bromide
ammonium chloride
ammonium iodide
ammonium molybdate
ammonium phosphate
ammonium sulphate
ammonium vanadate
borax:boric acid (7:3)

calcium chloride
magnesium chloride
sodium arsenate
sodium bisulphate
sodium silicate
sodium stannate
sodium tungstate
sodium vanadate
zinc chloride

THPC
potassium carbonate
potassium hydroxide
potassium dihydrogen phosphate
potassium thiocyanate
potassium bicarbonate
potassium carbonate
potassium molybdate

These chemicals were found to be incompatible with the neoprene and could not be applied to the fabric satisfactorily.

Further trials were made by immersing samples of nylon fabric in 10% solutions of the following chemicals:

ammonium chloride	thiourea
ammonium sulphate	zinc chloride
ammonium thiocyanate	borax:boric acid (7:3)

After the nylon samples were dried, a light coating of neoprene was applied but did not adhere to the fabric.

Nylon treated with a commercial thiourea formaldehyde type flame retardant was flame resistant but formed a melt which dropped off. When a coating of neoprene was applied the drip characteristic no longer existed but flaming did occur.

B. Polymers other than neoprene as melt inhibitors. Since attempts to make the neoprene coated fabric flame resistant were unsuccessful, it was decided to determine whether the char-producing effect was physical in nature, that it, one in which the rubber polymer held the nylon intact during combustion.

Three polymers were tried: Rhoplex (acrylic), Hycar (butadiene-acrylonitrile), and Vinylite VYHH (vinyl chloride-vinyl acetate copolymer). Nylon fabric samples were impregnated in varying concentrations of the above polymers then dried and cured. The treated fabrics were tested for drip resistance by igniting them with a match. As indicated in Table I, none of the samples formed the desired char.

TABLE I - Effects of Other Polymers as Coatings

	5%	10%	15%	20%
Rhoplex	BD*	BD	BD	BD
Hycar	BD	BD	BD	BD
Vinylite VYHH	BD	BD	BD	BD

* B - Sample burned.
D - Sample melted and dripped.

C. Effect of components of the neoprene formulation on melt. - When it was found that other polymers would not prevent flaming or produce a char, the chemical components of neoprene were investigated. Chloroprene was discounted as the major char producing component since similar chlorine containing polymers (VYHH) or butadiene type polymers (Hycar) did not exhibit the same effect. Coloring matter such as carbon black was also discounted as a cause.

Elimination of these components suggested that the zinc oxide additive may be responsible. Concentrations of 5, 10, 15, and 20 percent zinc oxide were dispersed in a 1% CMC solution and applied to the nylon. Flaming and dripping was not prevented on any of the samples.

Combinations of zinc oxide and various resin finishes were also tried. Results are shown in Table II.

TABLE II - Effects of Zinc Oxide in Combination with Various Resins

	Percent ZnO			
	5%	10%	15%	20%
Rhoplex	BD*	BD	BD	BD
Hycar	BD	BD	BD	BD
Vinylite VYHH	BD	BD	BD	pass
Aerotex Resin (UF) **	-	-	-	-

* B - Sample burned.
D - Sample melted and dripped.

** Was not suitable as a binding agent.

The above concentrations indicated promising results in only one case Although flame resistance was not obtained, a char was produced and no melting occurred with the VYHH in combination with 20% zinc oxide. This result indicated that a metallic oxide in combination with a chlorinated hydrocarbon was responsbile for producing a char and preventing the molten nylon from dripping.

Since flame resistance was not obtained with zinc oxide, antimony trioxide, commonly used in flame retardant finishes for cotton fabrics, was formulated with the Vinylite resin. Components in the following proportion were applied to the nylon:

Antimony Trioxide	20%
Vinylite VYHH	20%
Methyl Ethyl Ketone	60%

This formulation produced a fabric having a heavy add-on and a stiffness hand, but did not burn, melt or drip. Additions of chlorinated paraffin and tricresyl phosphate to improve the hand had an adverse effect and cause burning. Methoxyglycol acetyl ricinoleate and diethyl hexyl phthalate used in combination with each other were found to give a good hand without impairing the flame and drip-proof properties.

Applications to determine the most economical and suitable formulation were made and are shown in Tables III, IV, and V.

TABLE III - Effect of 50% Add-on at Various Concentrations

% VYHH	% Antimony Trioxide				
	5	10	15	20	25
5	BD*	BD	BD	BD	BD
10	BD	BD	BD	BD	BD
15	BD	BD	BD	BD	BD

* B- Sample burned.
D- Sample melted and dripped.

TABLE IV - Effect of 75% Add-on at Various Concentrations

% VYHH	% Antimony Trioxide				
	5	10	15	20	25
5	BD	BD	BD	BD	BD
10	BD	BD	BD	BD	BD
15	BD	BD	BD	D	D

TABLE V - Effect of 100% Add-on at Various Concentrations

% VYHH	% Antimony Trioxide				
	5	10	15	20	25
5	BD	BD	BD	BD	BD
10	BD	BD	BD	D	D
15	BD	B	B	pass	pass

Nylon fabric was coated with the above dispersions and dried at 100 deg. C. for 10 minutes. Table V indicates that combinations of 20% antimony trioxide and 15% VYHH provided the desired effect at add-ons of 100%. Fabric treated in this manner provided satisfactory flame resistance when tested according to Federal Specification CCC-T-191b, Method 5902, Flame Resistance of Cloth, Vertical in addition to being drip-proof.

It is possible that with further experimentation and improved methods of application, add-ons of less than 100% would be effective. Efforts to improve flame resistance by treatment of the nylon in NH4Cl solution prior to coating, resulted in poor adhesion of the coating.

Prevention of dripping is effected by the presence of solid materials such as the antimony oxide. (1) As the nylon is exposed to flame it melts and the viscosity of the melt is increased by the pigment. Due to the increased viscosity, the melt adheres to the fabric and does not drop off. The presence of the pigment alone, however, increases the tendency of nylon to flame.

Flaming is inhibited by the addition of the chlorinated polymer. Upon ignition, hydrochloric acid is liberated from the polymer. Reaction of the acid with the metallic oxide produces antimony oxychloride, an effective flame inhibitor. (2)

Relative proportions of the ingredients may be changed somewhat, However, in order to provide satisfactory flame resistance the ratio of metallic oxide to chlorinated polymer should fall preferably between 0.8 to 1.3.

IV. CONCLUSIONS

1. Based on an investigation of compounds responsible for causing neoprene coated nylon to form a crisp paper-like char without melting and dripping when ignited, it was found that coatings consisting of a combination of a metallic oxide and a chlorinated polymer will produce this effect.

2. Combinations of vinyl chloride with antimony trioxide in heavy add-ons (100% increase in weight) will make nylon flame resistant and inhibit the flow of molten nylon when in contact with a flame.

References

(1) Hasselstrom, Coles, et al, "Fire Resistance of Textiles, Nylon" Research Service Test Report No GC-29, P.3. (1 May 1951)

(2) Little, R. W., "Flameproofing Textile Fabrics", A.C.S. Monograph Series No. 104, Reinhold Publishing Corporation, New York, (1947)