

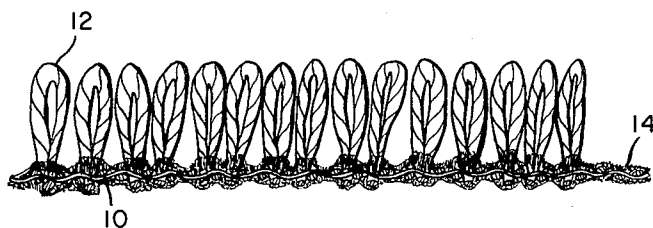
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PILE FABRICS AND PROCESS FOR TREATING SAME

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PILE FABRICS AND PROCESS FOR
TREATING SAME

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This invention relates to a method for imparting flame-retardant properties to pile fabrics prepared from flammable fibers. More particularly, this invention relates to a method of imparting flame-retardant properties to a pile fabric prepared from cellulosic and acrylic fibers without impairing the surface properties of the fabric.

Cellulosic and acrylic fibers have many properties which make them desirable for use in the preparation of tufted fabrics such as carpeting and lighter weight, fleece- and velvet-type fabrics. However, due to the high flammability of these fibers, particularly in pile fabric construction, their usefulness is seriously impaired. This is especially true in a deep pile construction in which the pile surface readily supports combustion.

Attempts to render pile fabrics containing cellulosic and acrylic fibers less flammable have met with little success. Although treatment with known flame-retardant materials reduces flammability, the resulting fabric is generally inferior in hand, with the softness and compliance of the original fibers being lost. In addition, such treatment involves additional processing steps, adding to the expense of preparing the fabric.

It is, therefore, an object of this invention to provide a process for rendering pile fabrics flame-retardant without impairing their aesthetic properties. It is a further object of this invention to provide a process which eliminates the necessity for applying the flame-retardant composition as a separate step in the process of preparing pile fabrics. Another object of this invention is to provide pile fabrics having flame-retardant properties which are prepared from combustible fibers.

The objects of this invention are achieved by a process which comprises applying a flame-retardant-containing composition to the backing of a pile fabric. Penetration through the backing is controlled so that the composition enters the base of the pile surface and coats the fibers for a distance of at least one-sixteenth inch.

Surprisingly, pile fabrics treated according to this process will not support combustion even when the surface of the uncoated flammable fiber ends are subjected to a direct flame. Furthermore, the fibers do not mat and stick together as might be expected but present a soft, aesthetically desirable surface without danger of flammability.

The present invention will be more fully understood by reference to the accompanying drawing in which the FIGURE is a transverse cross-sectional view of a pile fabric within the scope of the present invention. The fabric illustrated in the drawing is a tufted fabric with a loop pile surface and is comprised of a woven backing 10 and a plurality of loops 12 of pile yarn. The backing and a portion of the loops adjacent to the backing are coated with a flame-retardant material 14.

In practicing this invention, the flame-retardant-containing composition is applied to the porous backing of the pile fabric by brushing or by passing the fabric over a roller or series of rollers which dip into a coating pan. The level of application may be controlled by positioning a meter blade adjacent to the roller to control the amount of pick-up. The amount of penetration may be controlled by varying the viscosity of the coating material and by regulating the pressure on the fabric as it passes over the roller. Alternatively, the emulsion may be ap-

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plied by reversing the position of the fabric, i.e., with the pile surface facing downward, and applying the emulsion directly to the backing. A meter blade may be used to distribute the emulsion. The fabric may then be dried in a float-type, impinged air drying oven or by other suitable means. Drying conditions must, of course, be controlled to prevent damage to the fabric and the flame-retardant coating.

The term "flame-retardant" is used herein to mean burning very slowly in a confined area when exposed in air to a direct flame or burning not at all.

The process of this invention is particularly desirable in treating floor coverings, especially tufted carpeting. In preparing this type of floor covering, a film-forming emulsion is customarily applied to the backing. The flame-retardant material may be advantageously incorporated in the emulsion and applied to the backing with the emulsion.

In order to prevent the impairment of hand or other aesthetics of the fabric, the penetration of the flame-retardant composition should not extend to the tips of the fibers in the pile surface. It has been found that the fibers in most fabrics may be coated to within about one-fourth inch of their tips without impairing the hand or feel.

In addition to leaving the tips of the fibers uncoated, the emulsion or carrier for the flame-retardant material should be selected from a material which will readily penetrate the porous backing and when coated onto the fibers gives a continuous pliable film. It is not necessary that all of the fibers be coated; however, for best results, a major portion of the fibers in the tufts should be coated. Both natural and synthetic film-forming carriers may be used.

A wide variety of flame-retardant materials may be used. In general, any material may be selected which can be incorporated in a liquid solution, dispersion or emulsion which will penetrate the backing of the fabric and render cellulosic and acrylic fibers flame-retardant without loss of pliability. It has been found that phosphorus-containing materials are particularly desirable with those materials which are intumescent or include an intumescent agent being preferred. The expansion of the intumescent agent tends to extinguish a flame in a fabric of greater pile depth.

As previously indicated, the type of flame-retardant material used is not critical. For example, an intumescent coating composition comprising a 40% to 60% aqueous dispersion of a mixture consisting of 70% to 85% of non-film-forming intumescent solids and a sufficient amount of an aqueous film-forming latex of a polymer consisting of polyvinyl chloride, copolymers of vinyl chloride and other vinyl esters, copolymers of vinylidene chloride and vinyl chloride, copolymers of vinylidene chloride and acrylonitrile, or copolymers of styrene and butadiene to provide from about 15% to 30% of the polymer solids, based on the total weight of solids present, may be used. The non-film-forming intumescent solids may consist of a foam-forming substance, a non-resinous carbon-yielding substance, and an organic nitrogen compound. The non-resinous carbon-yielding substance may be a carbohydrate such as modified starch, water-dispersible protein such as gelatin and casein, or a polyhydric compound such as hexitol, e.g., mannitol, pentitols, mono- or di-tetritols such as mono- and dipentaerythritol. The organic nitrogen compound includes amino compounds such as dicyandiamide, urea, dimethyl urea, guanylurea phosphate, and glycine. The foam-producing agent may be mono-ammonium phosphate, diammonium phosphate, phosphoric acid, ammonium sulfate, sulfamic acid, ammonium sulfamate, ammonium bromide, sodium tungstate, or sodium borate.

Flame-retardant materials which generate an incombustible gas or form a fused mass of incombustible material such as diammonium phosphate, ammonium phosphate, sodium borophosphate, and monoammonium phosphate may also be used. Such materials include a carrier which may be selected from materials which form a pliable coating on the filaments, e.g., non-combustible halogen-substituted hydrocarbons which may be dispersed in a volatile organic solvent. The carrier solution may be mixed with an aqueous solution of the water-soluble inorganic flame-retardant component to form an emulsion which may be applied to the fibers as previously described. Generally, such a flame-retarding composition is prepared by using a composition comprised of 7 to 30 parts of the carrier, 20 to 40 parts of the volatile organic solvent, and 30 to 73 parts of the aqueous solution of the inorganic flame-retarding component. To promote emulsification of the organic and aqueous phases, conventional emulsifying agents such as sulfonated castor oil, ammonium linoleate, and another alkali metal soap or a sodium alkyl sulfonate with a water-soluble amine, e.g., triethylenetetramine, may be used. Suitable solvents include toluene, xylene, and the like.

Other flame-retarding compositions include compositions of the water-soluble reaction product of phosphoryl chloride and anhydrous ammonia in combination with an alkyd resin having free hydroxyl radicals. In addition to the aforementioned intumescent fire retardants, a composition may be prepared consisting of from about 10 to about 15 parts of tetrakis(hydroxymethyl)phosphonium chloride in 90 to 85 parts of a suitable latex-like carrier such as polyvinylidene chloride copolymers, polyvinyl chloride, copolymers of vinyl chloride and other vinyl esters, copolymers of vinylidene chloride and acrylonitrile, copolymers of styrene and butadiene, and the like. Other carriers such as natural and synthetic rubbers may be used.

The viscosity of the fire-retardant composition must, of course, be adjusted to give the proper degree of penetration for the particular fabric being treated. As previously indicated, the penetration must be sufficient to coat the major portion of the fibers in the pile for a distance of at least about one-sixteenth inch adjacent to the backing. However, the coating must not extend far enough towards the tips of the fibers to impair the hand or feel of the fabric.

The amount of latex applied to the backing will also vary, depending on the particular fabric being prepared. In the case of carpets, from about 15 to 30 ounces per square yard (dry weight) of the latex-like material will be applied. In the case of fleece-type fabrics used for apparel, from about 8 to 12 ounces will generally be applied.

The invention will be further illustrated but is not intended to be limited by the following examples in which parts and percentages are by weight unless otherwise specified.

EXAMPLE I

A tufted fabric was made from an acrylic fiber using a Model 30-30 tufting machine manufactured by the Broad Street Machine Co., Chattanooga, Tenn. The fiber used was a 15-denier per filament fiber prepared from a copolymer of 94% acrylonitrile and 6% methyl acrylate, cut to 3½ inch lengths. A 2.37-cotton count singles yarn with 2.5 S twist was prepared from this staple and converted to a three-play yarn with 3 Z twist. A ten ounce plain weave jute fabric was used as the backing for the tufted fabric. The acrylic yarn was stitched into the backing with seven stitches per inch along the rows and one-quarter inch spacing between rows. The machine was operated to give a cut pile having a height of ⅞ inch.

To 8 parts of a 50% emulsion of a 15/85 polyvinyl chloride/polyvinylidene chloride copolymer was added 20 parts of a mixture of paraformaldehyde, urea, ammonium phosphate, and boric acid, these ingredients being present

in the proportion of 2:2:1:1, respectively. The resulting mixture was diluted with 1.5 parts of water. The mixture was then brushed onto a 6-inch square of the fabric described in the preceding paragraph. With the dilution described, the penetration of the liquid past the backing and into the tufts of the fabric was approximately ⅛ inch. There was essentially no emulsion present in the outermost ⅜ inch of the tufts of the fabric. The latex was cured on the fabric by heating the latter at 70° C. for ninety minutes.

A control fabric was prepared by treating a 6-inch square of the same untreated fabric as described above except a 50% emulsion of the polyvinyl chloride/polyvinylidene chloride copolymer minus the other ingredients was used. This emulsion likewise penetrated about ⅛ inch into the tufts of the fabric. The two fabric samples were identical in appearance and surface hand.

To test for flammability, a hexamethylenetetramine pellet weighing 0.15 gram was placed in the center of each square of fabric and the fabric was placed in a draft-free location. The pellet was ignited with a match. The pellet itself then burned for approximately one hundred seconds in each case. In the case of the carpet sample treated with the emulsion containing paraformaldehyde, urea, ammonium phosphate and boric acid, the flame was contained within a small area of about ¾ inch in diameter adjacent to the pellet and did not continue after the hexamethylenetetramine pellet was consumed. The sample treated with the emulsion which did not contain these ingredients continued to burn until the entire fabric sample was consumed.

EXAMPLE II

Four (4) samples of the fabric described in Example I were treated to give penetration of fibers in the pile as shown in the following table. Each sample was tested for flame retardance and fabric hand. Compression work, defined as the area under a curve of load versus linear compression under loadings up to ten pounds per square inch (measured on an Instron Tensile Testing machine), was used as an objective measure of hand with the higher work values indicating fabrics which had favorable resilience characteristics.

Table

Depth of Penetration, Inch	Compression Work in Pounds per Inch	Flame Retardant Properties
0	0.83	None
⅛	0.82	Good
¼	0.78	Good
⅜	0.60	Good

As noted in the table, penetration of ⅛ inch was sufficient to impart flame retardance to the fabric.

EXAMPLE III

A pile fabric was prepared from 15-denier per filament rayon staple in a manner identical to that described in Example I except that the singles yarn was of 1.90 cotton count. The flame-retardant emulsion of Example I was brushed onto the backing of this fabric. A hexamethylenetetramine pellet weighing 0.15 gram was placed in the center of the sample and ignited. The flames were confined to a small area about three-quarters inch in diameter adjacent to the pellet and did not continue after the pellet was consumed.

EXAMPLE IV

A 1.92 cotton count cotton yarn was made into a 3-ply yarn and used to prepare a pile fabric as described in Example III. When this fabric was treated with the flame-retardant composition of Example I, and cured and tested for flammability as described in Example III, there was no burning of the fabric after the consumption of the

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hexamethylenetetramine pellet. The burning was limited to a very small area adjacent to the pellet.

EXAMPLE V

To samples of pile fabrics of the acrylic fiber of Example I, rayon and cotton prepared as in Examples III and IV, were applied the following compositions:

A.

	Parts
"Parlon" ¹ (chlorinated rubber) -----	15
Tricresyl phosphate -----	3.75
Toluene -----	31.25
Water -----	32
Mixture of ammonium phosphate and ammonium sulfate -----	16
Sulfonated castor oil -----	2

B.

Monoammonium phosphate -----	56
Dicyandiamide -----	10
Pentaerythritol -----	21.2
Titanium dioxide -----	12
Sodium alginate -----	0.6
Water -----	75
Copolymer of 75% vinyl chloride/25% vinylidene chloride, plasticized with 10% mono-octyl diphenyl phosphate -----	21

¹ Trade name of Hercules Powder Company.

In each case the liquid flame-proofing composition was applied with a fabric-covered paint roller. Penetration of the composition into the tufts of the fabric was about $\frac{1}{16}$ inch. Samples treated with composition A were dried at 70° C. for three hours. Samples coated with composition B were dried at 70° C. for one hour followed by a five-minute period at 150° C.

The pile surface of the fabric of each of the treated fabrics has the same hand and appearance as the untreated fabric prepared from the same fiber. There was no evidence of stiffening by the application of the flame-retardant composition. Each of the treated fabrics was subjected to the test of a burning hexamethylenetetramine pellet. In no case did the fabric continue to burn beyond the area adjacent to the pellet or after the pellet was consumed.

EXAMPLE VI

A sliver-knit pile fabric was prepared using a 3-denier per filament yarn from a 60/40 vinyl chloride/acrylonitrile copolymer as the backing fabric and a 3-denier per filament fiber prepared from a terpolymer of 93.7/6.0/0.3 acrylonitrile/methyl acrylate/sodium styrenesulfonate as the sliver. The fabrics were sheared to give a pile height of $\frac{3}{8}$ inch. After this shearing, the fabric weight was 13 ounces per square yard. An alkyd resin obtained by reacting phthalic anhydride and glycerol, manufactured by General Electric Company, and sold under the trade name "Glyptal," was mixed with 10% by weight, based on the weight of the resin, of polyphosphorylamide prepared as described in U.S. Patent 2,680,077. The product which was obtained as a granular mixture was dispersed in acetone. This dispersion was applied with a brush to the back of the sliver knit fabric.

Although a slight over-all stiffening of the fabric resulted, the face of the fabric was as soft and luxurious after the treatment as before. When a hexamethylenetetramine pellet was burned in the center of a 4-inch square of this fabric, there was no burning of the fabric beyond the area adjacent to the pellet and no burning after the pellet had been consumed. When a pellet was burned in the center of a 4-inch square of a piece of the same fabric which had been treated as described above with the resin minus the polyphosphorylimide, the entire face of the fabric was consumed.

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EXAMPLE VII

To the backs of the samples of tufted fabric from acrylic fiber and tufted fabric from cotton prepared as in Examples I and IV above, respectively, was applied an emulsion consisting of 20 parts of tetrakis(hydroxymethyl)phosphonium chloride dispersed in 100 parts of a latex containing 50% of a polyvinylidene chloride copolymer. The fabric was cured at 70° C. for ninety minutes. A hexamethylenetetramine pellet weighing 0.15 gram was placed in the center of a 4-inch square of each of these fabrics and was ignited. After the pellets had burned, there was no additional burning of either sample. The burned area was confined to a small area, about $\frac{3}{4}$ inch in diameter, adjacent to the pellet in each instance.

EXAMPLE VIII

The tufted fabric described in Example I was treated with the flame retardant composition described in that example. The composition which had a viscosity of about 2000 centipoises was placed in a supply trough of a standard carpet backing machine manufactured by the British Tufting Machine Company, Ltd. The fabric was moved at a speed of about 9 feet per minute in contact with $\frac{1}{3}$ of the surface of the applicator roll. The applicator roll which dipped into the supply trough was rotated to give a surface speed of about 50 feet per minute. An average of about 12 ounces per square yard of the flame-retardant composition was applied under these conditions. Average penetration into the pile was about $\frac{3}{32}$ inch. When tested for flammability, using a hexamethylenetetramine pellet weighing 0.15 gram, the flame was contained in an area about $\frac{3}{4}$ inch in diameter and did not continue after the pellet was consumed.

It will be apparent from the foregoing discussion and examples that the process of this invention may be utilized in imparting flame-retardant properties to all types of cellulosic and acrylic pile fabrics. These fabrics may be prepared by the tufting method or by knitting or weaving processes.

The type of material used in the backing is not critical so long as it is of porous construction. It may be felted, knitted, or woven. Both natural and synthetic, as well as flammable and non-flammable materials may be used.

The pile surface or tufts of the fabrics may likewise be prepared from both natural and synthetic fibers. Pile fabrics prepared from cellulose, regenerated cellulose, and cellulose ester fibers, e.g., cellulose acetate, cellulose propionate, and acrylic fibers which are known to propagate a flame, and in the pile fabric construction are readily consumed by flame if ignited, are advantageously rendered flame-retardant by the process of this invention. Among the acrylic fibers which may be used are those of acrylonitrile and copolymers of acrylonitrile containing at least 85% acrylonitrile and from 2% to 15% of one or more vinyl monomers which are copolymerizable with acrylonitrile, such as those mentioned in U.S. Patent 2,436,926 and U.S. Patent 2,743,994. These copolymers may contain from about 0.1% to about 10% of a copolymerizable monomer having sulfonic or sulfonate salt groups.

Although in many instances it will be desirable to incorporate the flame-retardant material into a latex-like emulsion, such as that normally applied to tufted carpeting, in some instances it may be preferable to apply the flame-retardant material alone to the backing and then either before or after drying to treat the fabric with a dispersion containing the latex-like material. In other instances, where the latex-like material is not desired, a dispersion or solution of the flame-retardant material alone may be applied to the backing of the fabric, thereby coating the base of the fibers in the tufts according to the process of this invention.

Many advantages accrue from the process of this invention. A high degree of flame retardation may be built into pile fabrics prepared from cellulosic and acrylic fibers without impairing their normal aesthetic

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qualities. In addition, this flame-retardant property is obtained without the necessity of using a complicated and involved process.

It will be apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

I claim:

1. A new article of manufacture comprising a pile fabric having a porous backing and a tufted surface, said surface being comprised of a major portion of flammable fibers selected from the group consisting of cellulosic and acrylic fibers, rendered flame-retardant by the presence of a coating of an intumescent flame-retardant material confined substantially to said backing and the portion of said tufted surface adjacent said backing, said coating being present on at least one-sixteenth inch of said fibers adjacent to said backing.

2. The article of claim 1 in which said acrylic fibers are prepared from a polymer comprised of at least 85% acrylonitrile.

3. The article of claim 1 in which the tips of said fibers are free from said coating for a distance of at least one-fourth inch.

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4. A pile fabric having a porous backing and a tufted surface prepared from fibers of a polymer comprised of at least 85% acrylonitrile rendered flame-retardant by the presence of a coating of a flame-retardant composition confined substantially to said backing and the portion of said tufted surface adjacent said backing, said coating being present on at least one-sixteenth inch of said tufted surface adjacent to said backing, said flame-retardant composition being comprised of a film-forming polymeric binder and an intumescent material capable of producing a fire-resistant carbonaceous foam.

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