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COMPOSITE TEXTILE FIBERS HAVING NON-WATER REVERSIBLE CRIMP

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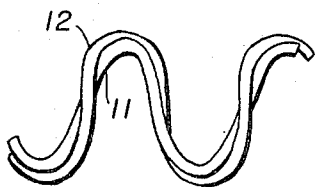


FIG. 1.

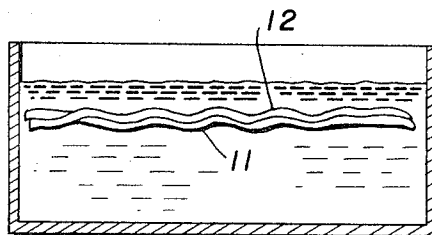


FIG. 2.

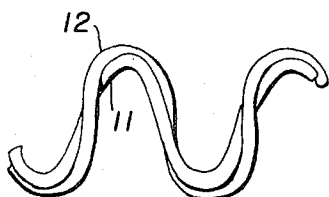


FIG. 3.

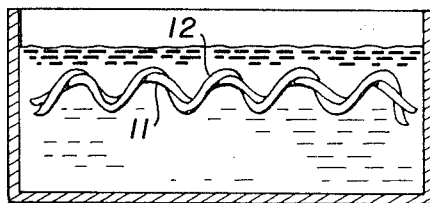


FIG. 4.

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COMPOSITE TEXTILE FIBERS HAVING NON-WATER REVERSIBLE CRIMP

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Continuation-in-part of application Ser. No. 796,064, Feb. 3, 1969, which is a continuation-in-part of application Ser. No. 314,781, Oct. 8, 1963. This application Nov. 21, 1969, Ser. No. 882,750

Int. Cl. D01d 5/28; D02g 1/00

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6 Claims

ABSTRACT OF THE DISCLOSURE

A composite acrylonitrile filament having non-water reversible crimp, stability of the crimp being achieved by controlling the ionizable groups in each component of the filament. The filament is also useful as a stuffing material.

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of United States application Ser. No. 796,064 filed Feb. 3, 1969 now abandoned, which is a continuation-in-part of United States application Ser. No. 314,781 filed Oct. 8, 1963 now abandoned.

This invention relates to multi-component synthetic filaments. More particularly, this invention relates to self-crimpable multi-component synthetic filaments which have a stable crimp.

BACKGROUND OF THE INVENTION

It is known to produce a multi-component or composite filament by extruding two or more spinning compositions through the same spinnerette orifice. By using spinning compositions which, when spun into fiber and stretched, exhibit different heat-shrinkage characteristics the composite fiber is self-crimpable. Upon being subjected to heat, such a fiber will curl. The curling or crimping is effected by the fact that one of the components of the fiber shrinks more than the other component, thereby pulling the fiber into a helical configuration. Fibers of this type and yarns of such fibers are used in fabrics and garments, such as sweaters, where a bulkiness is desirable. A sweater made from such a yarn is bulky, soft and provides extra warmth—as well as presenting a good appearance. Typically, fibers of this type are made from polymer pairs which are widely different in their susceptibility to being swelled or softened by water. Such fibers tend to be soft, limp, and straight when wet but develop a tight spiral crimp upon drying because of the greater shrinkage of the more heavily swollen polymer as it loses water. However, such yarns of such fibers are subject to several disadvantages. One of the major disadvantages of such known yarns is that the crimp is "reversible." That is, the developed crimp in these yarns is still sensitive to water and if the fiber is rewetted it again returns to its soft, limp and straight condition. When a sweater made of such yarn is washed, or when the wearer is caught in the rain, the amount of crimp in the yarn will change, thereby either changing the size or shape of the sweater a period.

When a sweater made of such a yarn is washed it must be handled very carefully during the drying. The sweater must not be deformed or out of shape during the drying operation. If, for example, the sweater is hung up to dry the weight of the water will deform the sweater, since the effect of the water is to release the crimp in the yarn, and will hold the sweater in a deformed and elongated condition as it dries, since the water will seep toward the lower portions of the sweater. Thus, when the sweater is dry it may be several inches longer than originally. Even if the sweater is carefully blocked out and laid on a flat

surface to dry there is no assurance that the sweater will retain its original shape and size after several launderings. The basis for the problem is that the water affects the yarn in such a manner that the yarn loses its crimp. The yarn will tend to regain its crimp upon drying, but this tendency is relatively weak and is not sufficient to pull the garment back into shape against the restraining forces imposed by the weight of the garment and the water retained therein.

This crimp "reversibility" is caused by the fact that, in known conjugate fibers, one of the components of the fiber swells in the presence of water to a greater extent than the other. In the usual case, the component inside the curls of the crimp in the fiber will swell to a greater extent, thereby causing the fiber to straighten and lose its crimp. With this in mind, one of the objects of this invention is to provide a novel and improved synthetic fiber.

Another object of this invention is to provide a multi-component or composite fiber which is self-crimpable and which is not altered in crimp characteristic or configuration by the application of water.

A further object of this invention is to provide a multi-component synthetic fiber in which the components have different shrinkage characteristics but which react in substantially the same degree to water.

Still another object of this invention is to provide a multi-component synthetic fiber in which the components have substantially the same reaction to tensile stress.

Still another object of this invention is to provide a stable and resilient stuffing material for pillows and cushions.

One embodiment of the present invention contemplates a multi-component, self-crimpable fiber in which the components of the fiber react in substantially the same degree to water and in which the components recover to substantially the same degree from tensile forces tending to pull the crimp out of the fiber.

More specifically the fiber of the present invention may be made up of two or more components of synthetic polymeric material, one of the components being adapted to shrink to a substantially greater degree in the presence of high heat than the other component. Each of the components has substantially equal hydrophilic character and substantially the same number of ionizable groups in the polymeric chain so that each component reacts to the same degree in the presence of a swelling agent such as water, thereby effecting a crimp stability in the presence of moisture. Further, each component has substantially the same degree of recovery from tensile load, so that the fiber has greater load bearing qualities and so that the crimp cannot be so easily pulled out of the fiber by tensile forces.

Other objects and advantages of the present invention will become apparent when the following detailed description is read in conjunction with the appended drawing, in which

FIG. 1 is an enlarged side view of a conventional multi-component fiber;

FIG. 2 is a side view of the conventional fiber of FIG. 1 showing the effect of water on the yarn;

FIG. 3 is an enlarged side view of a multi-component fiber of the present invention; and

FIG. 4 is a side view of the fiber of FIG. 3 showing the stability of the crimp in the presence of water.

Referring now in detail to the drawing, FIGS. 1 and 2 are included to show the effect of water on conventional composite fibers or yarns made therefrom. This conventional fiber is made up of two components 11 and 12 which have different heat shrinkage characteristics. The crimp shown in this fiber is effected by a heat treatment. One of the primary disadvantages of this conventional

fiber is that there is a great disparity in the reactions of the components to swelling agents such as water. FIG. 2 illustrates the result when such a fiber or yarn made therefrom is exposed to water, as in laundering or where the wearer is caught in the rain. The inner component swells in the presence of water, thereby taking the crimp out of the yarn fibers. This, of course, greatly enlarges the garment made from such a yarn.

FIGS. 3 and 4 illustrate the composite fiber of the present invention. By providing fiber components which react in substantially the same degree to water the crimp in the fiber is rendered stable. Since both components swell to the same degree the crimp does not change its configuration or degree, thereby insuring dimensional stability in the garment made of this fiber.

Swelling of the two components is controlled by controlling the number of ionizable groups in the polymer chain. The number of water-ionizable groups in the polymer chain of one component must be substantially the same as the number of water-ionizable groups in the polymer chain of the other component. Otherwise, the crimp in the filament will not be stable.

To control and render the crimp stable, the water-ionizable acid and basic groups in the polymer chains of the two components are held within certain limits. If the polymer chains of both components are the same, i.e., both acidic or both basic, then the difference between the two components, expressed in microequivalents per gram of polymer, should be less than about 45. If one of the components is acidic and the other basic, then the sum of the two, expressed in microequivalents per gram of polymer, should be less than about 45. However, in order to achieve maximum stability, it is preferred that this difference or sum be less than about 30. Stated in another manner, the two components fall under the following relationship:

$$N_1 - N_2 = 0 \pm 45$$

or preferably

$$N_1 - N_2 = 0 \pm 30$$

where N_1 is the acidic or basic characteristic, in microequivalents per gram of polymer, of one of the components, and N_2 is the like characteristic of the other component, expressed in the same manner, the values of N_1 and N_2 being expressed as positive values for acidic characteristics and negative for basic characteristics.

The number of ionizable groups present in either component is not critical provided only that the specified relationship between ionizable groups be maintained as disclosed herein.

Where, for example, the acrylonitrile polymers are prepared with a conventional peroxy-sulfoxy, i.e., redox, catalyst system, fragments of the catalyst and activator components are inherently incorporated into the polymer as ionizable acidic end-groups. Other ionizable groups may be present along the polymer chain as the result of the deliberate incorporation of such basic ingredients as vinyl pyridine or its homologues, or such acidic ingredients as itaconic acid or the styrene sulfonates. The use of such materials to alter the dyeing characteristics of monocomponent filaments is well known in the art.

The following examples illustrate fibers having components which fall within the specified relationship. These fibers exhibit excellent crimp stability under conditions met in laundering.

Example I

A spinning solution was prepared by dissolving in dimethyl acetamide a redox catalyzed copolymer of 93% acrylonitrile and 7% vinyl acetate. Another spinning solution was similarly prepared by dissolving in dimethyl acetamide a redox catalyzed copolymer of 85% acrylonitrile and 15% vinylidene chloride.

The two spinning solutions were forced in equal parts through a spinnerette orifice into an aqueous bath in a known manner to form composite filaments of about 5

denier. The composite filaments were withdrawn from the spin bath and passed through a conventional tow washer to remove solvent therefrom, a conventional 5× stretch being applied to the filaments as they passed through the washer. The stretched filaments were dried in conventional manner on steam-heated rolls and then exposed momentarily to saturated steam at 45 p.s.i.g. to accomplish differential shrinkage and crimp development. The filaments were cut to staple fiber lengths which showed excellent crimp stability when immersed in water at a temperature of 70° C. for 24 hours. Results of tests made to determine crimp stability are shown in Table I below.

Example II

A composite filament was formed by forcing two spinning solutions in equal parts through a spinning orifice following the procedure of Example I. One of the components of the filament was a redox catalyzed copolymer of 93% acrylonitrile and 7% vinyl acetate. The other component was a redox catalyzed terpolymer of 91% acrylonitrile, 7% vinyl acetate and 2% styrene. The composite filaments were withdrawn from the spin bath and passed through a tow washer to remove solvent therefrom, a 5× stretch being applied to the filaments as they passed through the washer. The stretched filaments were dried on steam-heated rolls and then momentarily exposed to saturated steam at 25 p.s.i.g. to accomplish the desired differential shrinkage and crimp development. There filaments showed excellent crimp stability in the presence of water at 70° C. Results of tests made to determine crimp stability of these filaments are shown in Table I below.

The following table illustrates the crimp stability of filaments made in accordance with the principles of this invention.

TABLE I

1	2	3	4
Sample run number	Crimp-dry, turns per inch (C_D)	Crimp-in water at 70° C., turns per inch (C_W)	Crimp variability, $\frac{C_D - C_W}{C_D} \times 100$ (percent)
A	55±5	57±5	3.7
B	36±2	37±3	2.8
C	41±2	43±3	4.9
D	48±2	46±2	4.2
E	96±3	96±3	3.1
F	91±3	90±3	1.1
G	87±3	88±3	1.2
H	11	0	100.00
J	12	0	92.00

The values shown in the above table were obtained by taking a length of crimped filament and counting the number of turns in a one-inch length of the dry filament in a relaxed state (i.e., under no tension). The actual length of the filament in such a one-inch length, if the filament were pulled straight, may be several inches. The filament was then immersed in water at 70° C. and another crimp count was made, whereupon the filament was dried and still another crimp count made. This procedure of counting the yarn crimp under alternating dry and wet conditions was done repeatedly. The values preceding the ± signs in columns 2 and 3 represent the average number of turns per inch over a number of measurements. The numbers following the ± signs represent the maximum deviation of the crimp count from the average value.

Sample runs A, B, C and D were made on filaments made in accordance with the procedure of Example I while runs E, F and G were made on filaments made in accordance with the procedure of Example II. Sample runs H and J, which were made on conventional water-reversible crimp acrylic conjugate filaments, are inserted in the table merely for illustrating the improved results obtained by the present invention.

Column 4 of Table II illustrates the crimp stability of a filament or yarn made in accordance with the present in-

vention. From these values of high crimp stability (low crimp variability), it can readily be seen that a garment made from these filaments will be dimensionally stable during the laundering operation, even without special care.

Example III

The components listed under Examples I and II were spun separately to form monocomponent filaments which were tested to determine the results listed in Table II below.

TABLE II

Component composition	Microequivalents/gm.		Recovery (percent)	Yield point (gm./den.)
	Acidic	Basic		
98% AN-7% VA-----	32	0	75±5	1.0
85% AN-15% VCl ₂ ----	21	0	79±5	1.0
91% AN-7% VA-2% S---	29	0	79±5	1.0

To determine recovery from tensile loads the filaments were stretched 2% and then released. The amount of stretch recovery was then measured. Over a number of such tests, the results shown in Table II under "Recovery" were achieved. The values preceding the ± signs in this column represent the average recovery, while the values following the ± represent the maximum deviation from the average.

A first "test fabric" in the form of a tufted pile carpet was made up on a conventional carpet tufting machine utilizing yarn of approximately 4,000 total denier made up from 15 denier filaments spun under the conditions of Example I. The uncut pile carpet had 48 tufts per square inch, 25 ounces of yarn per square yard, and a pile height of 1/4". The carpet was piece dyed and dried. Metal discs of 1 1/16 inch diameter were then positioned on opposite sides of the carpet at a number of points and loaded to compress the pile to 10 percent of its initial height. The carpet was held thus crushed for 24 hours after which the load was removed and the carpet was allowed to stand in air at approximately 60% relative humidity for 24 hours. The height of the pile which had been crushed was then measured to determine "dry recovery," dry recovery being the percentage of initial pile height to which the pile recovered (i.e., measured height divided by initial height times 100). Dry recovery was found to be in excess of 30 percent of the initial pile height, with average values in the range of 60 to 80 percent. The carpet was then immersed in 140° F. water for one minute without agitation. The carpet was then air dried and the height of the previously crushed pile was measured to determine "wet recovery," wet recovery being the percentage of initial pile height to which the pile recovered. Wet recovery was determined to be in excess of 50 percent of the initial pile height, with average values in the range of 80 to 98 percent.

A second "test fabric" was made up in the manner described above with the exceptions that the yarns were made up from 3 denier filaments spun in accordance with Example II. The yarns were made up by plying 16 ends of 20 singles, cotton count, with a twist of about 1/2 turns per inch to give a loose, bulky yarn. After the carpet was fabricated it was boiled for 30 minutes to simulate piece dyeing and then dried.

"Dry recovery" and "wet recovery" tests were then made as described. Dry recovery was found to be in excess of 30%, with average values in the range of 50 to 70 percent. Wet recovery was found to be over 50 percent, with average values in the range of 70 to 90 percent.

By utilizing components which have substantially the same recovery from tensile stresses, the filaments will have greater load bearing properties. Also, since each component recovers in substantially the same degree from tensile stresses (refer to Table II), the crimp is more stable under applied loads, i.e., when the tensile load is removed the filament is more likely to regain its crimp. This is especially of advantage at stress points such as sweater elbows. With conventional conjugate filaments or yarns, it

is very likely that bulging will occur in the fabric at such points as the elbows.

The filament of the present invention is especially useful as "fiberfill," i.e., cut into staple and used as a filling or stuffing for pillows, cushions, etc. While the average pillow is not laundered often, institutional pillows are laundered and often sterilized at frequent intervals. Conventional fiberfill will mat under this treatment, causing the pillow to lose its resiliency and become lumpy. Pillows filled with filament of the present invention, in staple form, can be laundered repeatedly without losing their resiliency and with only slight changes in size and contour.

What is claimed is:

1. A composite fiber comprising:

- at least two synthetic polymeric components each containing at least 80 percent acrylonitrile and up to 20 percent of at least one mono-olefinic monomer,
- said components being positioned in an eccentric contiguous adherent relationship,
- each of said components containing substantially equal number of ionizable groups per unit of weight,
- each of said components having equal hydrophilic character whereby said fiber is capable of developing crimp which is non-water reversible, and
- said fiber having when made into a test fabric a dry recovery of at least 30% and a wet recovery of at least 50%.

2. A composite fiber comprising:

- a synthetic polymeric component consisting of at least about 80 percent acrylonitrile and up to about 20 percent of at least one mono-olefinic monomer and a second polymeric component consisting of at least about 80 percent acrylonitrile and up to about 20 percent of at least one mono-olefinic monomer, the acrylonitrile in the two components having a difference in percentage level of at least about 0.5 percent,
- said components being positioned in an eccentric contiguous adherent relationship,
- each of said components containing substantially equal number of ionizable groups per unit weight,
- each of said components having equal hydrophilic character whereby said fiber is capable of developing crimp which is non-water reversible; and
- said fiber having when made into a test fabric a dry recovery of at least 30% and a wet recovery of at least 50%.

3. A composite fiber comprising:

- at least two synthetic polymeric components each containing at least 80 percent acrylonitrile and up to 20 percent of at least one mono-olefinic monomer,
- said components being positioned in an eccentric contiguous adherent relationship,
- said components having in the polymeric chains thereof ionizable groups which fall under the relationship

$$N_1 - N_2 = 0 \pm 30$$

where N_1 is the number of ionizable groups in the polymeric chain of one of said components, expressed in microequivalents per gram of polymer, and where N_2 is the number of ionizable groups in the polymeric chain of the other component, expressed in microequivalents per gram of polymer, said number being taken as positive for acid groups and negative for basic groups,

- each of said components having equal hydrophilic character whereby said fiber is capable of developing crimp which is non-water reversible, and
- said fiber having when made into a test fabric a dry recovery of at least 30% and a wet recovery of at least 50%.

4. A composite fiber comprising:

- at least two synthetic polymeric components, one of said components being a copolymer of acrylonitrile and vinyl acetate and the other said component

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being a copolymer of acrylonitrile and vinylidene chloride,

- (b) said components being positioned in an eccentric contiguous adherent relationship,
 (c) said components having in the polymeric chains thereof ionizable groups which fall under the relationship

$$N_1 - N_2 = 0 \pm 30$$

where N_1 is the number of ionizable groups in the polymeric chain of one of said components, expressed in microequivalents per gram of polymer, and where N_2 is the number of ionizable groups in microequivalents per gram of polymer, said number being taken as positive for acid groups and negative for basic groups,

- (d) each of said components having equal hydrophilic character whereby said fiber is capable of developing crimp which is non-water reversible, and
 (e) said fiber having when made into a test fabric a dry recovery of at least 30% and a wet recovery of at least 50%.

5. A composite fiber comprising:

- (a) at least two synthetic polymeric components, one of said components being a copolymer of acrylonitrile and vinyl acetate and the other component being a terpolymer of acrylonitrile, vinyl acetate and styrene,
 (b) said components being positioned in an eccentric contiguous adherent relationship,
 (c) said components having in the polymeric chains thereof ionizable groups which fall under the relationship

$$N_1 - N_2 = 0 \pm 30$$

where N_1 is the number of ionizable groups in the polymeric chain of one of said components, expressed in microequivalents per gram of polymer, and where N_2 is the number of ionizable groups in the polymeric chain of the other component, expressed in microequivalents per gram of polymer, said number being taken as positive for acid groups and negative for basic groups,

- (d) each of said components having equal hydrophilic

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character whereby said fiber is capable of developing crimp which is non-water reversible, and

- (e) said fiber having when made into a test fabric a dry recovery of at least 30% and a wet recovery of at least 50%.

6. A stuffing material comprising:

- (a) a composite fiber having at least two synthetic polymeric components each containing at least 80 percent acrylonitrile and up to 20 percent of at least one mono-olefinic monomer,
 (b) said components being positioned in an eccentric contiguous adherent relationship,
 (c) said components having in the polymeric chains thereof ionizable groups which fall under the relationship

$$N_1 - N_2 = 0 \pm 30$$

where N_1 is the number of ionizable groups in the polymeric chain of one of said components, expressed in microequivalents per gram of polymer, and where N_2 is the number of ionizable groups in the polymeric chain of the other component, expressed in microequivalents per gram of polymer, said number being taken as positive for acid groups and negative for basic groups,

- (d) each of said components having equal hydrophilic character whereby said fiber is capable of developing crimp which is non-water reversible, and
 (e) said fiber having when made into a test fabric a dry recovery of at least 30% and a wet recovery of at least 50%.

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