

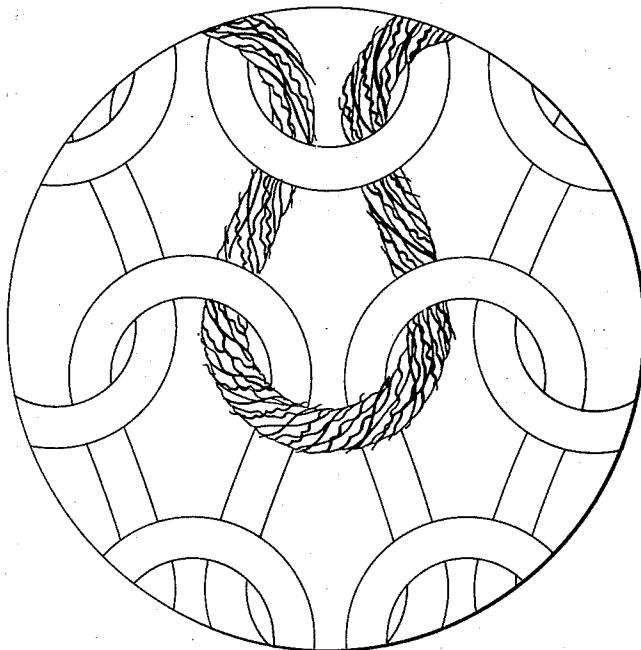
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ACRYLONITRILE POLYMER FABRICS

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ACRYLONITRILE POLYMER FABRICS

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1 Claim. (Cl. 28—78)

This invention is concerned with improved yarns and fabrics containing synthetic fibers.

Synthetic fibers have achieved notable acceptance for industrial and textile applications, but before they could be used widely for apparel fabrics, it was necessary that there be developed methods by which they could be handled readily and uniformly on existing commercial textile machinery. It was found, for example, that when synthetic fibers in staple length were used in applications where wool fibers had previously been used, they could not readily be made into yarns suitable for knitting or weaving. Because of the smooth surface and uniformity of synthetic staple fibers, they lacked cohesiveness, and card sliver prepared from these fibers tended to be fragile and readily split so that processing a card sliver was difficult. Moreover, woven and knitted fabrics made from synthetic fiber staple yarns are not equivalent to similar wool fabrics because the synthetic materials lacked the bulky resilient handle characteristic of woolen materials.

These two difficulties were ameliorated simultaneously by the discovery that introduction of a reasonable degree of crimp into synthetic fiber staple provide interfiber cohesiveness leading to satisfactory ease of fiber processing and yarn preparation, and at the same time gives to the finished fabric the desired loftiness, bulkiness and warm handle generally associated with wool fabrics. The preparation of crimped acrylic fibers is shown in U.S. Patent 2,747,233 to Hitt.

It is now known that most existing process steps can be carried out with synthetic fiber staple quite readily if the fibers are crimped. In general, staple fibers containing from 4 to 50 crimps per inch have been utilized, and no preference has been noted for any particular crimp level in this range. Currently accepted practice in the processing of synthetic staple fibers is to use fibers having between 8 and 12 crimps per inch.

Fabrics of synthetic fiber staple yarns are extremely easy to care for. They do not shrink in washing, and they dry rapidly. However, along with these advantages there are certain disadvantages, such as the tendency to pill. Pilling is a well-known phenomenon which may be described as the tendency to form small balls of inter-entangled fiber ends on the surface of a fabric.

Fabrics prepared from continuous filament yarns do not pill to any notable extent because there are very few loose fiber ends in any small surface area. Fabrics prepared from wool fibers pill just as readily as fabrics from synthetic fibers, but because of the lower tenacity of wool fibers, the pills break off rapidly as they are formed and there is little or no degradation of the fabric appearance. With synthetic fibers, however, when a pill forms, it is attached to the fabric surface by a few single fiber strands which, because of their high tenacity, are not readily broken, and, therefore, the pill remains. It is possible to brush or to clip such fabrics and remove such pills, but it would be desirable to provide fabrics with better pill resistance and with improved aesthetic properties.

According to this invention there are provided fabrics of acrylic staple fiber yarn, knitted with a courses per inch x wales per inch count of at least about 350, having

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improved resistance to pilling and greater aesthetic appeal along with greater softness and loftiness. These fabrics are prepared from a yarn comprising a blend of high and low shrinkage acrylonitrile polymer fibers, the weight ratio of low shrinkage fibers to high shrinkage fibers in the yarn being about 1.85, the low shrinkage fibers having a residual shrinkage of less than about 1% with less than 3 crimps per inch, and the high shrinkage fibers having a residual shrinkage of about 18 to 25% and having a mechanical crimp level of about 20 crimps per inch as measured immediately after the mechanical crimping process is completed and prior to fabric formation.

The drawing is a greatly enlarged plan view of fabric knitted as described except that an open structure is illustrated so that details are more readily visible.

In a preferred embodiment of this invention, fabrics are prepared from yarns having 11 turns per inch twist, of blended high-shrinkage and low-shrinkage fibers of acrylonitrile polymers containing at least about 85% combined acrylonitrile. In these blended yarns the fibers have a final size of 6 denier per filament or less. Preferably, the denier of the low shrinkage fibers is from 1 to 3, inclusive, and the high shrinkage fibers are about 3 denier. Such yarns are particularly suited to the manufacture of knitted sweaters with outstanding resistance to pilling and with particularly desirable aesthetic properties such as a soft, warm, light handle comparable to cashmere.

The crimp level at which these results are obtained is unexpectedly critical. Improved aesthetic qualities have always been sought, but no particular degree of crimp of fibers has been deemed by the art to be important for aesthetic values. The major value of crimped fibers has been thought, heretofore, to lie in processing characteristics; that is, the fiber should be crimped sufficiently so that the fibers hold together during the preparation of yarn.

It has now been found that the 8-12 crimps/inch which has been regarded heretofore as most satisfactory for commercial operation is the level which is least satisfactory for the production of fabrics which have outstanding aesthetic appeal and greatly improved resistance to pilling. All fibers in the yarns of this invention have a crimp level of from 0 to about 3 crimps per inch, or greater than about 17 crimps per inch.

The high-shrinkage and low-shrinkage acrylic fibers of this invention can be obtained in any one of several ways; for example, the high-shrinkage and the low-shrinkage yarns may have slightly varying chemical composition or may have been treated by different drawing processes or by different thermal processes at any of several stages in their preparation. One suitable way of obtaining blends of high-shrinkage and low-shrinkage yarns is to start with a heavy denier tow of acrylic fiber which already has a moderate degree of crimp. The precise level of crimp is not important at this stage. This tow is subjected to an additional drawing step and then is broken into staple fibers by the action of breaker bars (serrated or gear-like intermeshing opposed rollers with roughened surfaces which break the continuous filaments into random staple-length fibers). During the re-drawing and breaking operations, all crimp initially present in the tow is removed. Then, the broken sliver is crimped to any desired degree in a mechanical crimping process such as that already referred to above in U.S. Patent 2,747,233.

Following the crimping, a portion of the sliver is subjected, in a relaxed state, to a heat-treatment which

shrinks the fibers, leaving less than 5% residual shrinkage in the sliver. Preferably, the sliver, after the heat-treatment, retains less than 1% residual shrinkage. A portion of the sliver fibers which have not thus been relaxed and heat-set retains at least 15% residual shrinkage and preferably more than 18% residual shrinkage which will be activated by contacting with hot water. The two portions of sliver are then combined and drafted into a yarn and this yarn becomes a high bulk yarn when it is treated with hot water as, for example, in a dyeing process when the yarn is either in skeins or in the form of a finished fabric.

Pilling propensity can be measured by actual wearing or subjecting standard fabrics to precisely controlled laboratory treatments suited to develop the maximum level of pills on the surface. A number of laboratory treatments are available for the testing of pilling propensity. One is described in an article entitled "Random Tumble Pilling Tester" by E. M. Baird, L. C. Legere, and H. E. Stanley, *Textile Research Journal*, 26, 731-735 (1956). The testing process used in this article is the one employed in obtaining the results disclosed herein. Other methods for determining pilling tendency of fabrics are also available; for example, Technical Information Bulletin No. X-46 issued December 1955, by the Technical Service Section of the Textile Fibers Department of the E. I. du Pont de Nemours and Company, Incorporated, describes a means of determining the pill tendency of woven fabrics employing a brush and sponge pilling tester made by the Custom Scientific Instruments Company, Incorporated, of Arlington, New Jersey.

Aesthetic appeal, of course, is a subjective quality and cannot be measured by instruments without reference to individual preferences. However, it is possible to make a statistically significant estimate of aesthetic properties of two fabrics relative to one another by the use of a large number of individual opinions. Such opinions are obtained by presenting to each person of a selected group, two fabrics of which he is to select one as preferable to the other on aesthetic grounds. If such preferences are made on a number of samples with proper regard to back-checking to determine consistency of choice, and if a large enough number of opinions are so gathered, it is found that the opinions of one group so determined will agree in a statistically significant manner with the opinions of another different group who have evaluated the same fabrics. Thus, it is possible to rate fabrics for aesthetic appeal relative to one another and to be sure that such ratings have a real degree of validity.

In rating aesthetic appeal of fabrics, results may be expressed in a number of different ways. One convenient method, that used in the description which follows below, consists of comparing the total number of choices possible with the number of times any particular fabric is selected as preferable over a comparison fabric. That is, if a given fabric is compared with each of five other fabrics, it could be graded as more preferable or less preferable five times by each person making a choice. If twenty people participate in rating this group of fabrics, any one fabric can be selected 20×5 or 100 times. If a particular fabric is selected as preferable 75 times during this test, its aesthetic rating is 75%.

The following examples illustrate specific embodiments of the invention: All fabrics are sweaters prepared from fibers of acrylonitrile polymer containing about 94% combined acrylonitrile and about 6% methylacrylate spun into high bulk yarn; that is, a yarn containing both high-shrinkage and low-shrinkage staple fibers. The yarns are varied as the examples show to provide illustration of the effect of various construction factors on the aesthetic value and pilling tendency of the sweater fabrics. Sweaters are knit on a 24 gauge full-fashioned machine using a jersey stitch. Some of the examples in the table show a similar evaluation of commercial sweaters.

The acrylic fiber tow from which the yarns are made possessed about 8 crimps per inch, but this crimp is removed in the staple-forming process which redraws the yarn to give a tow free-of-crimp. Following breakage to form staple fiber sliver, the sliver is crimped at the level indicated and also subjected to a differential shrinkage treatment in which part of the sliver is heat-set and part of the sliver is not heat-set so as to set up the indicated shrinkage differential. Other means of introducing differential shrinkage are also satisfactory and any such technique is suited to the practice of the present invention.

It should be noted that crimp is needed in preparation of yarns only to permit easy formation of a staple sliver from loose staple. If the present invention is practiced employing very low crimp yarn, then it is advisable to use a yarn-spinning process which does not require formation of a card sliver, but rather permits the preparation of sliver direct from tow. If a high level of crimp is employed, it is also possible to form a conventional card sliver as in cotton or worsted systems and process the yarn into spun yarn without difficulty.

The residual shrinkage of all low-shrinkage fibers in the examples is less than 1%, and the residual shrinkage of all high-shrinkage fibers is 18-25%. The term "residual shrinkage" is the loss in length which a fiber or yarn will undergo when heated in a relaxed state with boiling water for 5 minutes. A yarn or fiber with a residual shrinkage of 18% will retract to 82% of its original length when heated under these conditions.

Examples 1-9 illustrate fabrics of this invention, and Examples 10-14 illustrate fabrics outside of the invention. Examples 11-14 are commercial sweater fabrics. Worsted count of all fabric yarns is $\frac{3}{2}$.

The pill level rating indicated in the tables has the following significance:

- (1)=very satisfactory—substantially no pills
- (2)=satisfactory—few pills
- (3)=borderline satisfactory—several pills
- (4)=objectionable—considerable pilling
- (5)=very objectionable—heavy pilling

The pill level in Example 1 through 10 was measured after actual wear test for the indicated number of hours. The laboratory pill test indicated for Example 10 through 14 was carried out on the Random Tumble Pilling Tester mentioned above. As shown in Example 10, wear test and laboratory test correlate very closely.

Practice of the present invention is suitable over a wide range of fabric constructions to produce superior fabrics so long as the primary requirements of crimp level and yarn shrinkage characteristics are met. If a crimp level outside of the range specified in this invention is employed, the aesthetic rating may be satisfactory, but the pilling propensity is very high. If fiber denier outside of the preferred range is employed, the aesthetic behavior of the fabric suffers accordingly. Examples 1 through 8 show preferred sweater fabric constructions. Example 10 shows a sweater construction outside the limits of the present invention, and it can be seen the results with this sweater are poor from an aesthetic standpoint and in pilling performance. Examples 12 through 14 are commercial sweaters purchased in the open market, laboratory tested and analyzed to determine their construction. These sweaters are satisfactory from an aesthetic standpoint, but are very poor in their pilling tendency. Only fabrics in which both crimp level and shrinkage requirements are in accord with the teachings of the present invention are superior in both factors. It is, of course, possible and within the scope of this invention to combine low crimp and high crimp fibers in the same yarn and still achieve superior results.

TABLE I

Example	Fiber Description				Yarn Description		Results	
	Denier		Ratio ³	Crimps/ in.	Turns Per Inch ⁵	Fabric ⁴ C x W	Pill Level	Aesthetic Rating, Percent
	Core ¹	Surf. ²						
1-----	4.5	2.0	1.85	20	9.7	350	{100 hrs.—1.4----- 200 hrs.—2.3-----	70
2-----	4.5	2.0	4.0	20	9.7	350	{100 hrs.—1.5----- 200 hrs.—2.1-----	74
3-----	3.0	2.0	2.7	20	9.7	350	{100 hrs.—1.4----- 200 hrs.—2.2-----	78
4-----	3.0	2.0	1.85	20	11.1	450	{100 hrs.—1.4----- 200 hrs.—2.2-----	78
5-----	3.0	2.0	2.7	20	11.1	450	{100 hrs.—1.2----- 200 hrs.—2.6-----	87
6-----	4.5	2.0	1.85	0	8.3	450	{100 hrs.—1.7----- 200 hrs.—2.8-----	71
7-----	6.0	2.0	1.85	0	8.3	350	{100 hrs.—1.1----- 200 hrs.—2.2-----	71
8-----	6.0	2.0	2.7	0	8.3	450	{100 hrs.—1.6----- Lab. test 3.1-----	74
9-----	3.0	2.0	1.85	20	9.7	350	{100 hrs.—2.4----- 200 hrs.—4.2-----	18
10-----	10.0	2.0	1.85	10	9.7	400	{Lab. test 4.5----- Lab. test 4.6-----	80-90
11-----	2.0	2.0	1.27	10	⁶ 9.7	470	{Lab. test 4.5----- Lab. test 4.8-----	70-80
12-----	2.0	2.0	1.27	10	⁶ 9.7	390		
13-----	2.0	2.0	1.27	10	⁶ 9.7	504		
14-----	3.0	2.0	1.27	10	⁶ 9.7	368		

¹ Denier of high-shrinkage fiber.² Denier of low-shrinkage fiber.³ Weight ratio of low-shrinkage fiber to high-shrinkage fiber.⁴ Courses per inch x wales per inch.⁵ As spun.⁶ Yarns removed from final fabric.

In addition to the fabrics indicated in Table I, Examples 1 through 14, other superior sweater fabrics have been prepared as described in Table II, Examples 15 through 25. These latter fabric illustrate three specific embodiments of the present invention, one being particular combinations of fine (below 6 denier) fibers, a second being the use of both high and low crimp in the same blended yarn, and the third being the use of low-shrinkage fibers of greater denier than the high-shrinkage fibers. Evaluation of the fabrics of Table II was completed in a manner similar to that described of the fabrics of Table I. All of the fabrics of Table II had an aesthetic rating of 70% or higher in paired comparison evaluations with control fabrics and other experimental fabrics. The results of pilling tests on the fabrics of Table II indicate that all of these fabrics would have a pill rating of less than 3 and frequently less than 2.

TABLE II

Example	Fiber Description				Ratio ²	Yarn, Turns/ inch ³	Fabric. ⁴ C x W
	Core		Surface				
	Denier	c.p.i. ¹	Denier	c.p.i. ¹			
15-----	2	0	1	0	1.35	11.2	450
16-----	2	0	1	0	1.35	11.2	500
17-----	1	0	1	0	1.35	11.2	450
18-----	6	20	1	20	2.63	9.7	400
19-----	6	0	3	0	1.85	11.2	450
20-----	3	0	2	20	1.85	11.2	450
21-----	3	20	2	0	1.85	11.2	450
22-----	2	22	3	22	1.85	11.2	450
23-----	2	0	3	0	1.85	11.2	450
24-----	3	0	3	0	1.85	9.7	450
25-----	1	22	4.5	22	1.40	11.2	450

¹ Crimps per inch.² Weight ratio of low-shrinkage fiber to high-shrinkage fiber.³ As spun.⁴ Courses per inch x wales per inch.

While the fiber characteristics already defined are necessary to the practice of the present invention, it is necessary, in order to obtain the highest quality fabrics, to take into account as well the interaction of all of the variables involved in fabric preparation. Outstanding sweater constructions, and the most preferable embodiment of the present invention, are shown in Examples 1

through 8, which illustrate the best combinations of some known key variables which contribute to desirable fabric aesthetics and greatest pill resistance, including crimps per inch, denier of core fiber and surface fiber, weight ratio of core fiber to surface fiber, yarn denier, twist multiplier and fabric tightness, as measured in the product of C x W (courses per inch x wales per inch) of the knit material.

While the above examples show the practice of the present invention in reference to knitted sweaters from blended yarns of high- and low-shrinkage fibers, it has also been found that woven fabrics from acrylic yarns of blended high-shrinkage and low-shrinkage fibers show the same behavior; that is, woven fabrics of superior aesthetic level and much improved resistance to pilling are obtained when the proper crimp level is chosen. In addition, the principles and practice of the present invention are not limited to acrylic fibers, but are also applicable to fabrics made from other synthetic fibers such as poly-(ethylene terephthalate). Pilling of fabrics from poly-(ethylene terephthalate) is reduced when either high or low crimp level is employed in tight fabric (e.g., product of C x W is 350 or higher) and when other variables are also controlled in accordance with the teaching of the present invention. The same is true of fabrics made from polyamide fibers and other synthetic fibers of like characteristics in which the amount of crimp can be controlled.

This application is a continuation-in-part of application Serial No. 704,333, filed December 23, 1957, now abandoned.

The claimed invention:

For providing improved resistance to pilling of tight fabric composed of high bulk, acrylonitrile polymer, staple fiber yarn, a fabric knitted in a courses per inch times wales per inch count of at least about 350 with 11 turns per inch yarn consisting of a blend of acrylonitrile polymer staple fibers of (1) low shrinkage 2 denier fibers having a residual shrinkage of less than 1% and less than 3 crimps per inch, and (2) high shrinkage 3 denier mechanically crimped fibers having a residual shrinkage of 18 to 25% and about 20 crimps per inch in a weight ratio of low shrinkage fibers to high shrinkage fibers of about 1.85 in the yarn, the fabric having a high

aesthetic rating, and exhibiting no more than a few pills when tested by the random tumble pilling tester method, after heat relaxation in boiling water.

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