An anti-static fleece or brushed fabric consisting essentially of acrylic fiber, polyester fiber, cotton fiber, wool fiber, nylon fiber or combinations of 2 or more thereof, characterized in that the fleece or brushed fabric has a basis weight of from 65 gsm to 400 gsm, contains from 0.1 wt % to 2 wt % of bicomponent anti-static fiber and is further characterized in that the fleece or brushed fabric exhibits a static decay time of less than 4 seconds. The woven or knit fleece or brushed fabric has permanent anti-static properties which do not wash out during laundering. A preferred yarn for making the fleece or brushed fabric is a composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament of from 2:1 to 8:1.
FIG. 1

STATIC DECAY TIMES FOR FLEECE
FIG. 2

(0.375% ANTI-STATIC FIBER) - MAGNIFICATION 25X
FIG. 3

WEFT YARNS - MAGNIFICATION 30X

FIG. 4

WEFT YARNS - MAGNIFICATION 440X
ANTI-STATIC FLEECE, BRUSHED FABRIC AND COMPOSITE YARN FOR THEIR MANUFACTURE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a non-provisional patent application based on co-pending U.S. Provisional Patent Application Ser. No. 62/328,770 (Attorney Docket No. APM 15-7/27620) titled “Anti-static Fleece for Apparel”, filed on Apr. 28, 2016, the priority of which is hereby claimed and the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention is directed to fabrics and yarns which have permanent anti-static (dissipative) properties when made into fleece or brushed fabrics. Garments made with the fleece or brushed fabric are suitable for children and adult next-to-skin wear.

BACKGROUND OF THE INVENTION

[0003] It is an object of the present invention to produce a synthetic based, or combination of synthetic and natural fiber, apparel weight, fleece or brushed fabric with permanent anti-static properties. Knitted fleece and brushed fabrics such as flannel, brushed polyester/cotton fabrics, brushed denim and so forth are of interest to the present invention. Anti-static filaments and yarns are known in the art, however their use in next-to-skin wear has traditionally been avoided due to a variety of issues, including appearance, dyeability, and hand. Hand refers to texture, drapeability, stretch, wrinkle resistance and so forth.

[0004] Permanent static dissipation in fleece and brushed fabrics is difficult to achieve. This is because of the nature of the surface nap or pile where static build-up is prevalent. Without intending to be bound by any theory, it is believed the extremely high surface area of fleece and brushed fabrics is especially prone to static build-up throughtribological interaction with adjacent surfaces. Anti-static filaments and fibers (typically of dark color) are traditionally used mostly in carpets, relatively heavy protective garments, multilayer fabric structures and liners where the anti-static material is more easily hidden and neither hand nor appearance becomes an issue. See, for example, United States Patent Application Publication No. US 2013/0065470. Examples of industrial wear fleece garments are seen online, available from Barnet, producers of the brand Negastat®. These items of clothing are typically dark colored and not next-to-skin type items. Negastat® brand fleece safety wear is used as a liner within a jacket, for instance.

[0005] Representative prior art related to anti-static conductive fibers includes:

US 2008/0226909—(Ascend Performance Materials)—Bicomponent electrically conductive drawn polyester fiber and method for making same;

U.S. Pat. No. 5,876,849—(Itex)—Cotton/nylon fiber blends suitable for durable light shade fabrics containing carbon doped anti-static fibers;

US 2015/025499A1 (Southern Mills)—Fabric containing an intimate blend of anti-static fibers arranged in a pattern;

WO 2006/042504 (IonPhasE Oy)—Anti-static fibers;

U.S. Pat. No. 7,537,830 B2 (DuPont)—Flame retardant spun staple yarns;

[0006] WO 2015/051370 A2—articles of apparel effective to regulate temperature of the wearer;

CN 104514075 A—Antistatic polar fleece and manufacture thereof;

CN 2133597 —Antistatic knit wool shirt and trousers having conductive wires.

[0007] There remains a need in the industry for fleece or brushed fabric which is suitable for next-to-skin wear, having permanent anti-static properties as well as hand and appearance comparable to existing fabrics without conductive fiber.

SUMMARY OF THE INVENTION

[0008] The present invention provides an anti-static fleece or brushed fabric wherein the presence of the anti-static fiber is masked because of its low content in the fleece or fabric and/or because it is incorporated into the fleece or brushed fabric as a component in a composite anti-static filamentary yarn. The composite anti-static filamentary yarn comprises anti-static bicomponent filament wrapped with non-conductive filament. The anti-static fiber thus has minimal impact on the aesthetics and hand of the products. Moreover, the products of the invention exhibit surprising anti-static properties as is seen in the examples which follow.

[0009] Generally speaking, the invention is directed in one aspect to an anti-static fleece or brushed fabric consisting essentially of acrylic fiber, polyester fiber, cotton fiber, wool fiber, nylon fiber or combinations of 2 or more thereof, characterized in that the fleece or brushed fabric has a basis weight of from 65 gsm to 400 gsm, contains from 0.1 wt % to 2 wt % of bicomponent anti-static fiber and is further characterized in that the fleece or brushed fabric exhibits a static decay time of less than 4 seconds.

[0010] In another aspect, the invention is directed to a composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament of from 2:1 to 8:1.

[0011] Advantages and features of the invention are appreciated by reference to the Figures. In FIG. 1, it is seen that fleece prepared in accordance with the invention exhibits surprisingly short static decay times, despite very low loading of anti-static fibers. FIG. 2 shows that the anti-static yarns employed maintain their continuity despite the very aggressive fleece manufacturing process. FIGS. 3, 4 illustrate a particularly preferred composite anti-static filamentary yarn used for manufacturing anti-static fleeces and brushed fibers.

[0012] Still further features and advantages of the invention will be appreciated from the discussion which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention is described in detail below with reference to the Figures, in which:

[0014] FIG. 1 is a histogram showing the anti-static decay times of fleeces of the invention and an anti-static fleece without anti-static fiber;

[0015] FIG. 2 is a photomicrograph showing an anti-static well yarn incorporated into a fleece of the invention;

[0016] FIG. 3 is a photomicrograph of composite anti-static filamentary well yarns of the invention comprising anti-static bicomponent filament wrapped with non-conductive filament; and
FIG. 4 is a photomicrograph of a cross-section of a composite anti-static filamentary yarn weft of FIG. 3.

FIG. 5 is a perspective illustration of an antistatic bicomponent fiber having 3 carbon black surface stripes;

FIG. 6 is an illustration of a cross-section of the antistatic bicomponent fiber of FIG. 5 having the carbon black surface stripes; and

FIGS. 7A, 7B and 7C are illustrations of cross-sections of antistatic bicomponent filaments and yarns useful in connection with the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

As used in the specification and claims, the singular forms “a”, “an” and “the” include plural references unless the context clearly dictates otherwise. For example, the term “an article” may include a plurality of articles unless the context clearly dictates otherwise.

Terminology has its ordinary meaning, for example, gsm refers to basis weight in grams per square meter, percents, ppm and so forth are based on weight and so forth.

An “anti-static bicomponent fiber” refers to a fiber with 2 or more distinct components defining at least one electrically conductive component and at least one relatively non-conductive component.

As used herein, the terminology “electrically conductive component” means a component with a lower resistivity than an “electrically non-conductive fiber-forming component”. “Conductive”, “anti-static” and like terminology refers to anti-static compositions and more conductive compositions such as electrostatic dissipative (ESD) compositions having a volume resistivity of somewhat less than about 10^{12} ohms/cm. Anti-static compositions generally have volume resistivities between about 10^6 ohms/cm to somewhat less than 10^{15} ohms/cm while ESD compositions have volume resistivities in the range of 10^6 ohms/cm to 10^8 ohms/cm. Electrically non-conductive compositions generally have volume resistivities of greater than 10^{10} or 10^{12} ohms/cm, but higher than an electrically conducting component in any event. The electrically conductive component generally has a volume resistivity in the range of from about 10^6 ohms/cm to less than 10^{10} ohms/cm, depending upon loading of the carbon black, while the associated non-conductive component has a higher volume resistivity. The overall resistivity of the fiber reflects the resistivity of the components.

“Consisting essentially of” and like terminology refers to the recited components and excludes other ingredients which would substantially change the basic and novel characteristics of the composition, article or process. Unless otherwise indicated or readily apparent, a composition or article consists essentially of the recited or listed components when the composition or article includes 90% or more by weight of the recited or listed components. That is, the terminology excludes more than 10% unrecited components.

A “brushed fabric” is a knitted or woven fabric upon which brushes or other abrading devices are used to permit the fibers in the yarns to be raised to create a nap or surface texture on the fabric.

“Fiber” and like terminology refers to filament (continuous) fibers and staple fibers. Most natural fibers such as cotton and wool, are staple fibers. Synthetic fibers, such as nylon and polyester, are considered filament fibers. The natural fiber silk is also a filament fiber, but when filament fibers are cut short, they are considered staple fibers. Staple fiber lengths are typically less than 10 cm (4 inches). “Yarn” refers to yarn spun from staple fibers or yarns formed from 2 or more filamentary fibers.

“Fleece” refers to a soft, fuzzy fabric (woven or knitted) usually knitted on a circular knitting machine which is napped and sheared on one or both sides. To achieve the napped surface structure, the material is typically fed through a napper. The napper runs mechanical bristles along the cloth, raising the surface of the textile. Next, the cloth is usually sent to a shearing machine, which uses a precision blade to cut the fibers raised by the action of the napper to provide a surface which sprouts a layer of cut fibers. Fleeces may be made as multilayer structures; however fleeces of the invention are advantageously produced as single layer anti-static fleeces.

The polymer of the conductive and non-conductive fiber may consist of one or more synthetic polymers. The bicomponent fiber product may have one component comprising about 70-98 wt % of the fiber made up of Nylon-66 doped with about 2-30 wt % TiO_2 and another component comprising about 2-30 wt % of the product made up of Nylon-6/carbon black composition. The denier range for the resulting bicomponent product is anywhere from about 15-100 denier optionally with surface stripes of Nylon-6/carbon black, with one preferred range of about 20-25 denier for single and double filament products. Delustered compositions have been found to be light in color in spite of the high loadings of carbon black, having an L* target color value of 55. The fiber resistivity of this light-colored antistatic fiber product is in the range of about 5x10^6 ohms/cm to less than about 5x10^9 ohms/cm. Fabric testing methods include the following: Static Decay Methods—EN 1149-3, Surface Resistance AATCC Method 76, Static Decay Methods—Fed Std 191 Method 5931; electrostatic clinging of fabrics, Fabric-to-Metal Test AATCC Method 115 as well as the other test methods discussed hereinafter.

The polymer components of the synthetic polymer filamentary fibers or staple fibers can be composed of any suitable melt spun or thermoplastic fiber-forming polymers and copolymers. By “fiber-forming” is meant the property of linear, high molecular weight polymers making such capable of being formed into fibers of useful strength and toughness. Suitable polymers include polyolefins such as polyethylene and polypropylene; polyamides and copolyamides (nylon, such as polyhexamethylene adipamide (Nylon-66), polymeric E-caprolactam (Nylon-6), polyaminoundecanoic acid, polymers of bis-paranaminocyclohexyl methane and undecanoic acid; polystyrenes; polyesters, such as those of polymeric hydroxy-carboxylic acid esters and of terephthalic or isophthalic acids and lower alkylene glycols such as ethylene glycol and tetramethylene glycol; polyurethanes; polyureas; polycarbonates; polyvinyl halides; polynylidene halides, etc., as well as acrylic fibers. Acrylic fibers or polyacrylic fibers include fibers made with at least 85% by weight polyacrylonitrile monomer and up to 15% by weight neutral ester comonomer and modacrylic fibers with at least 55% by weight polyacrylonitrile monomer and up to 50% by weight comonomer. Likewise, the synthetic polymer fibers, filaments and yarns may be texturized in some embodiments.

For better adherence of the constituents in a bicomponent filament, it is preferred that the polymers of both constituents be selected from the same polymer genus.
Polymers may be modified by incorporation of delustrants, dye-enhancing materials, dye-resisting materials, etc. The preferred polymers are polyesters, Nylon-6 or Nylon-66, with Nylon-66 containing no more than about 30 wt % delustrant, TiO₂, so as to produce the light colored resulting yarn.

[0032] The carbon black compounded in the polymer of one of the anti-static bicomponent fibers must be of the electrically conductive type and should retain its conductive nature in the textile article formed at least in part from the bicomponent filaments. By “electrically conductive carbon black” is meant any carbon black which has a specific resistivity of less than 200 ohm/cm as measured by ASTM Method D991-68. A resistance of less than 1x10⁵ ohms/cm is preferred. The carbon black may be dispersed in the polymer forming the conductive constituent of the bicomponent filament by known mixing procedures, provided that an end result of at least 3 stripes are found on the single fiber formed. Excessive shearing of the black is to be avoided in that the conductivity of the black can be substantially reduced thereby. Sufficient dispersion of the black in the polymer should be accomplished under conditions that result in a minimum reduction in the conductivity character of the black.

[0033] The amount of carbon black compounded in the polymer of one of the constituents should only be sufficient to impart the desired low resistance to the electrically conductive component. It is understood in the art that various definitions of “conductive” exist. Herein, the term “conductive” is intended to mean materials that enable moderate levels of electric current flow, as is seen above.

[0034] The bicomponent filament is preferably round in cross-section, although multi-lobal cross-section may be desired for certain end uses. It is, however, important that the cross-sectional area of the conductive constituent comprises only a minor amount of the total cross-sectional area of the filament. Cross-sectional areas of the conductors are directly translatable into volumes of the respective constituents composing the filament. The cross-sectional areas of the conductive constituent should comprise about 1 to 30 percent of the cross-sectional area of the filament. Preferably the percent is 3 to 12. Below 1 percent, the effectiveness of the static electricity dissipation may be too low for many uses; and with such a low volume of such conductive constituent, it is difficult to assure that the constituent is not completely enveloped with the non-conductive polymer component. When the percent of cross-sectional area of the conductive constituent exceeds 30, adherence of the constituent is reduced, as well as the tensile strength of the filament, since most of the tensile strength of the filament is derived from the non-conductive constituent. No-Shock® type fibers and most anti-static competitive products typically have relatively low tenacity values, and are often in the denier range of about 2.0-10.0 dpf.

[0035] The interface of the two constituents in the subject invention should be curvate. The cross-section of the non-conductive constituent normally has a shape such that the non-conductive constituent partially encapsulates the conductive constituent. Providing such a cross-section configuration ensures better adherence between the two dissimilar constituents and reduces the noticeable presence of the black component on the surface of the filament to a mere stripe of low visibility. The non-conductive constituent partially encapsulates the black-containing constituent in an amount of at least 50 percent. Preferably, the average percent encapsulation should be between about 66-95. By “percent encapsulation” is meant the percent of extruded periphery of the stripes occupied by the non-conductive constituent, as hereinafter described and illustrated.

[0036] The following test methods may be employed in connection with determining properties of the invention anti-static bicomponent fibers, yarns and fabrics.

Test Methods and Properties

[0037] Unless otherwise specified, any industry standard test method refers to the version in effect as of Apr. 1, 2017 and conditioning and testing is conducted at 50% RH and 21°C, allowing for equilibration. At least 3 specimens of each sample are tested, unless otherwise stated.

[0038] Fiber Resistivity is measured by Test Method A: fiber or yarn resistivity is measured using a Keithley Model 6517 Electrometer. The apparatus and procedure are as follows:

Apparatus

[0040] 2. Shielded test enclosure with Semi-automatic clamping device.
[0041] 3. 100 mega ohm resistor.

Setup

[0043] 1. Electrode spacing is 7.5 cm.
[0044] 2. Set air pressure on fixture cylinder to 30 psi with air stripper on.
[0045] 3. The Configuration is set by the Windows program.

Procedure

[0046] 1. Double click the Resistance Meter icon to open the application.
[0047] 2. There will be a “Calibrate” box and “Enter New Merge” on the left side of the screen. Click on the “New Merge Retrieve Results” box. You can enter a new merge or retrieve information (on results already performed you cannot change any pre-existing information).
[0048] 3. Open the cover door, place the 100 MΩ resistor between the clamps, and the flip switch to close clamps. Note: the pressure gauge should be set at 30 psi.
[0049] 4. When the resistor is in place, close the door and click “Calibrate”. If the calibration is within limits, a “Calibration is in Limits” message box will pop up. Click “Okay” and begin testing. If the calibration is out of limits, click “Okay”, and check the resistor to be sure it is making good contact, and then recalibrate.
[0050] 5. Resistor reading should be between (9.8x10⁹~0.2) Ω. Note: Calibration will print out on result sheet when testing is complete.
[0051] 6. Open the door and remove the resistor and close the door back.
[0052] 7. Open the cover, thread fiber through pretension guides and into the aspirator. Make sure the filaments or yarn is over the clamps. If the specimen is set up already, tie in the yarn.
measures the whiteness of materials. The L* value measures the relative difference between black = 0 and white = 100. A Byk-Gardner Color Sphere Color System is used, specifically a utilizing a Byk-Gardner model TCS 8800 Colorimeter or equivalent. Measurements are made at room temperature (i.e., at about 23°C) using a compression cell with 5 gram specimens of filament fiber therein, air flushed to form an entangled substrate for analysis. Testing is performed on duplicate specimens. Preferred anti-static bicomponent filaments exhibit L* values of greater than 50.

Denier (ASTM D 1577) is the linear density of a fiber as expressed as weight in grams of 9000 meters of fiber. Usually, the fiber is conditioned at 55±2% relative humidity, and 75°±2°F. On the package for a specified period, usually 24 hours when the monofilament has aged more than ten days since being made. A 0.9 meter sample of monofilament is weighed and denier is calculated as the weight of a 9000 meter sample in grams. Denier times (10/9) is equal to denier (dtex). Denier and tenacity tests performed on samples of staple fibers are at standard temperature and relative humidity conditions prescribed by ASTM methodology.

Specifically, standard conditions mean a temperature of 70°±2°F. (21°±1°C) and relative humidity of 65% ±2%.

Basis Weight values are obtained according to FTMS191A: 5041.

Anti-Static Fiber Construction and Preparation

Referring to FIGS. 5 and 6, there is shown an anti-static bicomponent fiber 10 comprising an electrically conductive component 12 and an electrically non-conductive fiber-forming component 14. The electrically conductive component includes a matrix polymer loaded with carbon black in order to provide conductivity. Electrically non-conductive fiber-forming component 14 comprises a polymer such as a nylon. It is appreciated that the electrically non-conductive component 14 is the majority of material (more than 50 wt % of the fiber) and that it defines an elongate fiber structure 16 generally indicated in FIG. 1. Anti-static bicomponent fiber 10 is further characterized in that electrically conductive component 12 is arranged in 3 separate, equally spaced as shown, electrically conductive stripes 18, 20 and 22 extending along a length, L, of anti-static bicomponent fiber 10. Stripes 18, 20 and 22 are spaced apart from each other over an outer periphery 24 of fiber 10 such that outer surfaces 30, 32 and 34 of stripes 18, 20 and 22 are exposed and the inner portions 36, 38 and 40 are at least partially and preferably mostly encapsulated by electrically non-conducting component 14 (FIG. 2). The stripes are thus separated by electrically non-conducting component 14.

Anti-static bicomponent fibers 10 are generally uniform in cross-section along their length. The degree of encapsulation of electrically conductive component 12 is conveniently calculated as a percentage by summing the cross-section perimeter lengths of the conductive stripes in contact with electrically non-conductive, fiber-forming component 14, dividing by the sum of the cross-section perimeter lengths of the stripes (both the encapsulated and unencapsulated portions) and multiplying by 100%.

FIG. 7A is a diagram of a cross-section of a 2 filament anti-static bicomponent yarn including 2 filaments
generally having the construction of the filament of FIGS. 5 and 6, wherein the features are designated by like numerals.

[0074] FIGS. 7B and 7C are diagrams of cross-sections of other 2 filament bicomponent yarn useful in connection with the present invention wherein the features are designated with like numerals as in FIGS. 5 through 7A. The electrically conductive components 12 extend along the length of the filaments and the electrically non-conductive fiber-forming components 14 define elongate fiber structure. The yarns shown have a denier per filament (dpf) of from about 1.5 to 15.

[0075] The anti-static fibers and yarns used in connection with the present invention are preferably made by utilizing a conjugant melt extrusion spinning process as is known in the art and described in the references enumerated above.

[0076] Note, particularly, U.S. Pat. No. 3,969,559. Spinning of anti-static biconstituent filaments is suitably accomplished by melt co-extruding a plurality of different polymer compositions in a spinning apparatus provided with coextrusion capability and a spinnerette plate adapted to conjugate the streams into the desired structure. The spinnerette typically employs a plurality of converging branched capillaries of suitable size and geometry which conjugate the components into the desired structure as it is extruded.

[0077] If so desired, the anti-static bicomponent fibers of the invention may be blended with non-conducting fibers to prepare yarns suitable for apparel, either as a blended filamentary yarn as hereinafter described or as a blended staple yarn. Anti-static bicomponent fibers are particularly suitable for being added in minor amounts to a larger bundle of normal non-conductive synthetic filaments or fibers prior to spinning or during drawing or draw texturing thereof. The bicomponent fibers in filament fiber form can be cut to desired staple lengths and blended with non-conductive staple fibers using conventional means. The blended fibers can then be spun into yarn having anti-static qualities.

[0078] Various features of the invention include in particular, polyester and blends thereof, as well as a bicomponent yarn with the purpose to provide permanent static dissipative properties in fleece and brushed fabrics. The antistatic fiber may be used as filamentary or staple spun yarn and is used in knitting and/or weaving with the purpose to provide the static dissipative properties in the product. While polyester may be used to exemplify the invention, it is understood that numerous polymers may be used herein without deviating from the present scope of the invention.

[0079] In any embodiment, an anti-static intimately blended staple fiber made into a fleece fabric comprising a bicomponent polymer (polyester)/cotton/conductive component fiber at about a content of 49/49/2% (+/−1%), in a fleece fabric suitable for next-to-skin children and adult wear having permanent antistatic properties. The fabric comprises a conductive component content of about 0.5-2.0% (+/−2%). The conductive component may be carbon black, silver or tin oxide. Other preferred polymers include nylon 6, nylon 66, and the fabric may include up to about 12% spandex (85% Polyurethane/ 15 Polyester copolymer) based on OWG (on weight of good). The spandex is preferably in the range of 1-6% and most preferably about 1-3% spandex. One preferred fleece construction is a single-layer knitted fleece.

[0080] Bicomponent extruded fibers typically have two phases, which are inseparable (i.e., not removable) from each other during normal wear of a garment, unlike anything that has been coated, doped, or treated topically with carbon which tends to abrade off during knitting and weaving. The abrasion process results in dust on machines and fabric, and lowers the effective use time of garments in normal wear and laundering. Most preferred is a single layer fleece or brushed fabric which is wearable, washable, is not heat melted and not waterproof.

[0081] The anti-static fiber can have multiple configurations of the conductive component. It can be a surface or core/sheath conducting technology.

EXAMPLES

[0082] A polyester cotton intimate blended yarn (49.5%/49.5%/1% No-Shock® staple) with 1.5 inch staple length is used to create a circular knit fabric which generates the back of a fleece garment. A pile is created through brushing or sueding. The No-Shock® staple portion of the fiber may be a 3 surface stripe product. The resulting fabric provides a resistance rating of 107 ohms per square and eliminates nuisance static that builds up in normal use by a child wearer. With lack of nuisance static build up, the garment prevents nuisance shock as well as dust build up under industry standard conditions (low humidity environment).

[0083] Brushed or suede polycotton knitted fabric can be used to produce onesies for infant wear. This is one application for the inventive fleece garment.

[0084] A non-exhaustive list of products currently available which are next-to-skin fleece but do not have permanent antistatic properties include those found for sale by online retailers as follows. In general these products contain either all, or predominately all, cotton (natural fibers) or polyester fibers.

[0085] PagamaGram;
[0086] Micro polar fleece Big Feet Pajama Company;
[0087] Roudelain stretch fleece—Lord & Taylor;
[0088] Girls (size 4-14) Carters fleece one piece fleece PJ's—Kohl's;
[0089] Fleece romper (baby)—diapers.com—100% polyester;
[0090] Baby fleece onesie w/feet—Magic Beans;
[0091] Infant rompers fleece—6pm.com—100% polyester;
[0092] Fleece sleeper PJ's—Kmart;
[0093] UGG Kids—fleece onesies—100% polyester;
[0094] Target/Carter's newborn onezie's—Pattern: dyed pattern; Material: 100% Cotton.

[0095] For exemplary calculation purposes, if one had a 100 g/m of circular knit fabric, 0.4% loading of an intimately blended yarn would yield 0.5 grams carbon conductor.

[0096] 100 g±0.04-4 g NS (no shock conductor)
[0097] 0.5% NS yarn goes into knit fabric and makes 10% NS yarn. In 100 g fabric
[0098] 100 g±0.1±0.05-0.5 g carbon (active conductor).

[0099] The antistatic feature of this invention is imparted by the surface contact of the yarn allowing it to dissipate the electrical charge. Generally, alternate fibers are not level, continuous, or even so as to surface contact with the resistivity test. The art generally must twist fibers to form an antistatic yarn when blended with a cotton, or natural yarn to achieve the desired dissipative property. In the 1950's, generally two yarns were used and twisted together. The
current solution is to have 2 plus ply yarns and different methods of spinning the yarn.

Here, the invention can also include: 10-35% nylon, 65-90% cotton and 0.01-0.5% carbon. The fibers are an intimate blend, and soft to the touch. The invention may utilize either core-sheath or surface stripe technology depending on the end application and test method. In some embodiments, the present invention employs surface-striped anti-static bicomponent fibers that can remove nuisance level shock (about $10^{-10}$ per square surface resistance) from a resulting garment.

Static Decay of Fleece

Knitted fleece was prepared from polyester yarn and minor amounts of bicomponent anti-static yarn having a basis weight of 195 gsm. The fleeces were constructed at different loadings (in percent by weight of the fleece) of anti-static fiber in the weft direction. Results are seen in Table 1 below and are presented graphically in FIG. 1.

<table>
<thead>
<tr>
<th>Loading</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.45</td>
<td>5.8</td>
<td>6.23</td>
<td>5.83</td>
<td>5.83 ± 0.28</td>
</tr>
<tr>
<td>0.375</td>
<td>0.15</td>
<td>0.16</td>
<td>0.17</td>
<td>0.18</td>
<td>0.17 ± 0.01</td>
</tr>
<tr>
<td>0.5</td>
<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
<td>0.15</td>
<td>0.14 ± 0.01</td>
</tr>
</tbody>
</table>

Static decay time of fleece with anti-static yarn showed 35 times faster dissipation than control, even at very low loading which was surprising. The fleeces loaded with bicomponent anti-static yarn passed the cling test noted above.

It is critical to maintain the continuity of the anti-static fiber in the fleece production process in order to retain static dissipation properties at such low loadings.

FIG. 2, a photomicrograph showing an end view in section of the fleece having 0.375 wt % anti-static fiber, shows that during fleece production the antistatic yarn was not damaged in spite of the aggressive process required to produce the fleece. This result was also unexpected and is likely necessary for superior control of surface static electricity.

Composite Anti-Static Filamentary Yarn

A particularly preferred aspect of the invention is to use a composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament in a weight ratio of non-conductive filament: anti-static bicomponent filament of from 2:1 to 8:1 as shown in FIGS. 3 and 4. Generally the composite anti-static filamentary yarn has an overall denier of from 30 to about 300, typically from about 50 to 200 and from about 75 to 125 in some preferred embodiments.

FIG. 3 is a photomicrograph (300x) of a plurality of filamentary weft yarns prepared by wrapping four filament anti-static filamentary yarn with non-conductive polyester yarn. The antistatic filamentary yarn had a denier of approximately 25, with a dpf of approximately 5-6. The polyester filamentary yarn had a denier of approximately 70 with a dpf of slightly greater than 1. The larger diameter anti-static filaments are indicated by the arrows in FIG. 3. FIG. 4 is a photomicrograph (440x) showing an enlarged cross-section of one of the wrapped filament yarns shown in FIG. 3. The anti-static filaments appear on the left in darker color.

There is thus provided in Embodiment No. 1 an anti-static fleece or brushed fabric consisting essentially of acrylic fiber, polyester fiber, cotton fiber, wool fiber, nylon fiber or combinations of 2 or more thereof, characterized in that the fleece or brushed fabric has a basis weight of from 65 gsm to 400 gsm, contains from 0.1 wt % to 2 wt % of bicomponent anti-static fiber and is further characterized in that the fleece or brushed fabric exhibits a static decay time of less than 4 seconds.

Embodiment No. 2 is the anti-static fleece or brushed fabric according to Embodiment No. 1, wherein the fleece or brushed fabric exhibits a static decay time of less than 3 seconds.

Embodiment No. 3 is the anti-static fleece or brushed fabric according to Embodiment Nos. 1 or 2, wherein the fleece or brushed fabric exhibits a static decay time of less than 1 second.

Embodiment No. 4 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the fleece or brushed fabric exhibits a static decay time of less than 0.25 seconds.

Embodiment No. 5 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the fleece or brushed fabric exhibits a static decay time of less than 0.1 seconds.

Embodiment No. 6 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the fleece or brushed fabric contains from 0.25 wt % to less than 1.5 wt % of bicomponent anti-static fiber.

Embodiment No. 7 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the fleece or brushed fabric contains less than 1 wt % of bicomponent anti-static fiber.

Embodiment No. 8 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, in the form of a fleece consisting essentially of acrylic fiber, cotton, polyester and mixtures thereof.

Embodiment No. 9 is the anti-static fleece according to Embodiment No. 8, wherein the fleece is a knitted fleece.

Embodiment No. 10 is the anti-static fleece according to Embodiment Nos. 8 or 9, wherein the fleece has a basis weight of from 70 gsm to 500 gsm.

Embodiment No. 11 is the anti-static fleece or brushed fabric according to Embodiment No. 10, wherein the fleece has a basis weight of from 75 gsm to 250 gsm.

Embodiment No. 12 is the anti-static fleece or brushed fabric according to Embodiment Nos. 8 through 11, wherein the fleece consists essentially of cotton, polyester or mixtures thereof.

Embodiment No. 13 is the anti-static fleece or brushed fabric according to Embodiment Nos. 1 through 7,
in the form of a woven brushed fabric consisting essentially of cotton, polyester and mixtures thereof.

[0120] Embodiment No. 14 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the acrylic fiber, polyester fiber, cotton fiber, wool fiber, nylon fiber is staple fiber, incorporated into the anti-static fleece or brushed fabric as spun yarn.

[0121] Embodiment No. 15 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the bicomponent anti-static fiber is incorporated into the anti-static fleece or brushed fabric as filamentary fiber.

[0122] Embodiment No. 16 is the anti-static fleece or brushed fabric according to

[0123] Embodiment No. 15, wherein the bicomponent anti-static fiber is incorporated into the anti-static fleece or brushed fabric in a composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament of from 2:1 to 8:1.

[0124] Embodiment No. 17 is the anti-static fleece or brushed fabric according to Embodiment No. 16, wherein the non-conductive filament is textured filament.

[0125] Embodiment No. 18 is the anti-static fleece or brushed fabric according to Embodiment No. 17, wherein the non-conductive filament is textured polyester and the anti-static fleece or brushed fabric consists essentially of polyester or consists essentially of a mixture of polyester with cotton.

[0126] Embodiment No. 19 is the anti-static fleece or brushed fabric according to any of the foregoing Embodiments, wherein the bicomponent anti-static fiber comprises an electrically conductive component and an electrically non-conductive fiber-forming component, wherein:

(a) the electrically conductive component comprises a matrix polymer and carbon black; and

(b) the electrically non-conductive fiber-forming component comprises a fiber-forming polymer, said electrically non-conductive fiber-forming component defining an elongate fiber structure of the anti-static bicomponent fiber.

[0129] Embodiment No. 20 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static fiber and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static fiber are the same polymer.

[0130] Embodiment No. 21 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static fiber and the polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static fiber are different polymers.

[0131] Embodiment No. 22 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static fiber and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static fiber are selected from polyester polymers, polyamide polymers, polyleakylene polymers and polyacrylic polymers.

[0132] Embodiment No. 23 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static fiber and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static fiber are polyamide polymers.

[0133] Embodiment No. 24 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static fiber is Nylon-6 and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static fiber is Nylon-66.

[0134] Embodiment No. 25 is the anti-static fleece or brushed fabric according to Embodiment Nos. 19 through 24, wherein the electrically conductive component of the bicomponent anti-static fiber is present in an amount of from 2 wt % to 30 wt % based on the weight of the bicomponent anti-static fiber and the non-conductive fiber-forming component is present in an amount of from 70 wt % to 98 wt % based on the weight of the bicomponent anti-static fiber.

[0135] Embodiment No. 26 is the anti-static fleece or brushed fabric according to Embodiment No. 25, wherein the electrically conductive component of the bicomponent anti-static fiber is present in an amount of greater than 5 wt % based on the weight of the bicomponent anti-static fiber.

[0136] Embodiment No. 27 is the anti-static fleece or brushed fabric according to Embodiment No. 26, wherein the electrically conductive component of the bicomponent anti-static fiber is present in an amount of from 7.5 wt % to 15 wt % based on the weight of the bicomponent anti-static fiber.

[0137] Embodiment No. 28 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein carbon black is present in an amount of from 10 wt % to 50 wt % based on the weight of the electrically conductive component of the bicomponent anti-static fiber.

[0138] Embodiment No. 29 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein carbon black is present in an amount of from 25 wt % to 40 wt % based on the weight of the electrically conductive component of the bicomponent anti-static fiber.

[0139] Embodiment No. 30 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the anti-static bicomponent fiber exhibits an electrical resistance of less than 10^{10} ohms/cm as measured by Test Method A using a Keithley 6517 Electrometer.

[0140] Embodiment No. 31 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the anti-static bicomponent fiber exhibits an electrical resistance of from 5 \times 10^{6} ohms/cm to 5 \times 10^{8} ohms/cm as measured by Test Method A using a Keithley 6517 Electrometer.

[0141] Embodiment No. 32 is the anti-static fleece or brushed fabric according to Embodiment No. 19, wherein the anti-static bicomponent fiber exhibits an electrical resistance of from 10^{6} ohms/cm to 10^{7} ohms/cm as measured by Test Method A using a Keithley 6517 Electrometer.

[0142] There is provided in Embodiment No. 33 a composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament of from 2:1 to 8:1.

[0143] Embodiment No. 34 is the composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to
Embodiment No. 33, wherein the anti-static bicomponent filament is wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament 3:1 to 6:1.

**[0144]** Embodiment No. 35 is the composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to Embodiment Nos. 33 or 34, wherein the anti-static bicomponent filament is wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent of from 3.5:1 to 5:1.

**[0145]** Embodiment No. 36 is the composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to Embodiment Nos. 33 through 35, having a yarn denier of from 30 to 300.

**[0146]** Embodiment No. 37 is the composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to Embodiment No. 36, having a yarn denier of from 40 to 150.

**[0147]** Embodiment No. 38 is the composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to Embodiment Nos. 33 through 37, wherein the anti-static bicomponent filament has a single filament denier of from 2 to 20.

**[0148]** Embodiment No. 39 is the composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to Embodiment No. 38, wherein the anti-static bicomponent filament has a single filament denier of from 3 to 7.

**[0149]** Embodiment No. 40 is the composite anti-static filamentary yarn according to Embodiment No. 39, wherein the non-conductive filament has a single filament denier of from 0.5 to 3.

**[0150]** Embodiment No. 41 is the composite anti-static filamentary yarn according to Embodiment No. 40, wherein the non-conductive filament has a single filament denier of from 0.75 to 2.

**[0151]** Embodiment No. 42 is the composite anti-static filamentary yarn according to Embodiment Nos. 33 through 41, wherein the non-conductive filament is textured filament.

**[0152]** Embodiment No. 43 is the composite anti-static filamentary yarn according to Embodiment No. 42, wherein the anti-static filament is textured polyester.

**[0153]** Embodiment No. 44 is the composite anti-static filamentary yarn according to Embodiment Nos. 33 through 43, wherein the bicomponent anti-static filament comprises an electrically conductive component and an electrically non-conductive fiber-forming component, wherein:

- **[0154]** (a) the electrically conductive component comprises a matrix polymer and carbon black; and
- **[0155]** (b) the electrically non-conductive fiber-forming component comprises a fiber-forming polymer, said electrically non-conductive fiber-forming component defining an elongate filament structure of the anti-static bicomponent filament.

**[0156]** Embodiment No. 45 is the composite anti-static filamentary yarn according to Embodiment No. 44, wherein the matrix polymer of the electrically conductive component of the anti-static filament and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static filament are the same polymer.

**[0157]** Embodiment No. 46 is the composite anti-static filamentary yarn according to Embodiment No. 44, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static filament and the polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static filament are different polymers.

**[0158]** Embodiment No. 47 is the composite anti-static filamentary yarn according to Embodiment Nos. 44 through 46, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static filament and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static filament are selected from polyester polymers, polyamide polymers, polyalkylene polymers and polyacrylic polymers.

**[0159]** Embodiment No. 48 is the composite anti-static filamentary yarn according to Embodiment No. 47, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static filament and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static filament are polyamide polymers.

**[0160]** Embodiment No. 49 is the composite anti-static filamentary yarn according to Embodiment Nos. 44 through 48, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static filament is nylon-6 and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static filament is nylon-66.

**[0161]** Embodiment No. 50 is the composite anti-static filamentary yarn according to Embodiment Nos. 44 through 49, wherein the electrically conductive component of the bicomponent anti-static filament is present in an amount of from 2 wt % to 30 wt % based on the weight of the bicomponent anti-static filament and the electrically non-conductive fiber-forming component is present in an amount of from 70 wt % to 98 wt % based on the weight of the bicomponent anti-static filament.

**[0162]** Embodiment No. 51 is the composite anti-static filamentary yarn according to Embodiment No. 50, wherein the electrically conductive component of the bicomponent anti-static filament is present in an amount of greater than 5 wt % based on the weight of the bicomponent anti-static filament.

**[0163]** Embodiment No. 52 is the composite anti-static filamentary yarn according to Embodiment No. 51, wherein the electrically conductive component of the bicomponent anti-static filament is present in an amount of from 7.5 wt % to 15 wt % based on the weight of the bicomponent anti-static filament.

**[0164]** Embodiment No. 53 is the composite anti-static filamentary yarn according to Embodiment Nos. 44 through 52, wherein carbon black is present in an amount of from 10 wt % to 50 wt % based on the weight of the electrically conductive component of the bicomponent anti-static filament.

**[0165]** Embodiment No. 54 is the composite anti-static filamentary yarn according to Embodiment No. 53, wherein carbon black is present in an amount of from 25 wt % to 40 wt % based on the weight of the electrically conductive component of the bicomponent anti-static filament.

**[0166]** Embodiment No. 55 is the composite anti-static filamentary yarn according to Embodiment Nos. 44 through 54, wherein the anti-static bicomponent filament exhibits an
electrical resistance of less than $10^{10}$ ohms/cm as measured by Test Method A using a Keithly 6517 Electrometer.

[0167] Embodiment No. 56 is the composite anti-static filamentary yarn according to Embodiment No. 55, wherein the anti-static bicomponent filament exhibits an electrical resistance of from $5 \times 10^6$ ohms/cm to $5 \times 10^7$ ohms/cm as measured by Test Method A using a Keithly 6517 Electrometer.

[0168] Embodiment No. 57 is the composite anti-static filamentary yarn according to Embodiment No. 56, wherein the anti-static bicomponent filament exhibits an electrical resistance of from $10^7$ ohms/cm to $10^8$ ohms/cm as measured by Test Method A using a Keithly 6517 Electrometer.

[0169] While the invention has been described in detail, modifications within the spirit and scope of the invention will be readily apparent to those of skill in the art. Such modifications are also to be considered as part of the present invention. In view of the foregoing discussion, relevant knowledge in the art and references discussed above in connection with the foregoing description including the

[0170] Detailed Description and Background of the Invention, the disclosures of which are all incorporated herein by reference, further description is deemed unnecessary. In addition, it should be understood from the foregoing discussion that aspects of the invention and portions of various embodiments may be combined or interchanged either in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to limit the invention.

What is claimed is:

1. An anti-static fleece or brushed fabric consisting essentially of acrylic fiber, polyester fiber, cotton fiber, wool fiber, nylon fiber, or combinations of 2 or more thereof, characterized in that the fleece or brushed fabric has a basis weight of from 65 gsm to 400 gsm, contains from 0.1 wt % to 2 wt % of bicomponent anti-static fiber and is further characterized in that the fleece or brushed fabric exhibits a static decay time of less than 4 seconds.

2. The anti-static fleece or brushed fabric according to claim 1, wherein the fleece or brushed fabric exhibits a static decay time of less than 1 second.

3. The anti-static fleece or brushed fabric according to claim 2, wherein the fleece or brushed fabric exhibits a static decay time of less than 0.25 seconds.

4. The anti-static fleece or brushed fabric according to claim 1, wherein the fleece or brushed fabric contains from 0.25 wt % to less than 1.5 wt % of bicomponent anti-static fiber.

5. The anti-static fleece or brushed fabric according to claim 4, wherein the fleece or brushed fabric contains less than 1 wt % of bicomponent anti-static fiber.

6. The anti-static fleece or brushed fabric according to claim 1, in the form of a fleece consisting essentially of acrylic fiber, cotton, polyester and mixtures thereof.

7. The anti-static fleece according to claim 6, wherein the fleece has a basis weight of from 75 gsm to 250 gsm.

8. The anti-static fleece according to claim 6, wherein the fleece consists essentially of cotton, polyester or mixtures thereof.

9. The anti-static fleece or brushed fabric according to claim 1, wherein the acrylic fiber, polyester fiber, cotton fiber, wool fiber, or nylon fiber is staple fiber, incorporated into the anti-static fleece or brushed fabric as spun yarn.

10. The anti-static fleece or brushed fabric according to claim 1, wherein the bicomponent anti-static fiber is incorporated into the anti-static fleece or brushed fabric in a composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament of from 2:1 to 8:1.

11. The anti-static fleece or brushed fabric according to claim 1, wherein the bicomponent anti-static fiber comprises an electrically conductive component and an electrically non-conductive fiber-forming component, wherein:

(a) the electrically conductive component comprises a matrix polymer and carbon black; and

(b) the electrically non-conductive fiber-forming component comprises a fiber-forming polymer, said electrically non-conductive fiber-forming component defining an elongate fiber structure of the anti-static bicomponent fiber.

12. The anti-static fleece or brushed fabric according to claim 11, wherein the matrix polymer of the electrically conductive component of the bicomponent anti-static fiber and the fiber-forming polymer of the electrically non-conductive fiber-forming component of the bicomponent anti-static fiber are polyamide polymers.

13. The anti-static fleece or brushed fabric according to claim 11, wherein the electrically conductive component of the bicomponent anti-static fiber is present in an amount of from 2 wt % to 30 w % based on the weight of the bicomponent anti-static fiber and the non-conductive fiber-forming component is present in an amount of from 70 wt % to 98 wt % based on the weight of the bicomponent anti-static fiber.

14. The anti-static fleece or brushed fabric according to claim 13, wherein the electrically conductive component of the bicomponent anti-static fiber is present in an amount of greater than 5 wt % based on the weight of the bicomponent anti-static fiber.

15. The anti-static fleece or brushed fabric according to claim 13, wherein the anti-static bicomponent fiber exhibits an electrical resistance of from $5 \times 10^6$ ohms/cm to $5 \times 10^7$ ohms/cm as measured by Test Method A using a Keithly 6517 Electrometer.


17. The composite anti-static filamentary yarn comprising anti-static bicomponent

16. wrapped with non-conductive filament according to claim 16, wherein the anti-static bicomponent filament is wrapped with non-conductive filament in a weight ratio of non-conductive filament:anti-static bicomponent filament 3:1 to 6:1.

18. The composite anti-static filamentary yarn comprising anti-static bicomponent filament wrapped with non-conductive filament according to claim 16, having a yarn denier of from 30 to 300.

19. The composite anti-static filamentary yarn according to claim 16, wherein the bicomponent anti-static filament comprises an electrically conductive component and an electrically non-conductive fiber-forming component, wherein:

(a) the electrically conductive component comprises a matrix polymer and carbon black; and
(b) the electrically non-conductive fiber-forming component comprises a fiber-forming polymer, said electrically non-conductive fiber-forming component defining an elongate filament structure of the anti-static bicomponent filament.

20. The composite anti-static filamentary yarn according to claim 19, wherein the electrically conductive component the bicomponent anti-static filament is present in an amount of from 2 wt % to 30 wt % based on the weight of the bicomponent anti-static filament and the non-conductive fiber-forming component is present in an amount of from 70 wt % to 98 wt % based on the weight of the bicomponent anti-static filament.

* * * * *