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(54) **Bicomponent fibers**

(57) The present invention relates to a thermoplastic bicomponent fiber consisting of (a) a first component which consists of polyethylene terephthalate, polybutylene terephthalate, or nylon, and (b) a second component which is olefinic and which forms at least a portion of the fiber's surface, wherein the second component

(b) comprises a blend of at least one grafted linear high density polyethylene or linear low density polyethylene having pendant succinic acid or anhydride groups with a high density polyethylene.

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Description

[0001] The present invention relates to thermoplastic bicomponent fibers exhibiting superior properties and a method for their preparation. These bicomponent fibers are characterized by contacting under thermally bonding conditions (a) a first component comprising at least one high performance thermoplastic polymer, and (b) a second component comprising a blend of at least one high density polyethylene (HDPE) and at least one grafted linear ethylene polymer having pendant succinic acid or succinic anhydride groups. The bicomponent fibers can be prepared by coextruding (a) and (b) into fiber having a sheath/core or side-by-side configuration. The bicomponent fiber can be coextruded using melt blown, spunbond or staple fiber manufacturing process conditions. The present invention also relates to a method of bonding high performance fibers using the thermoplastic bicomponent fibers of the present invention as binder fibers.

[0002] Bicomponent fibers are usually produced by melt spinning. In this procedure, each molten polymer is extruded through a die, with subsequent drawing of the molten extrudate, solidification of the extrudate by heat transfer to a surrounding fluid medium, and taking up of the solid extrudate. Melt spinning may also include cold drawing, heat treating, texturizing and/or cutting. An important aspect of melt spinning is the orientation of the polymer molecules by drawing the polymer in the molten state as it leaves the die. In accordance with standard terminology of the fiber and filament industry, the following definitions apply to the terms used herein:

A "monofilament" (also known as "monofil") refers to an individual strand of denier greater than 15, usually greater than 30;

A "fine denier fiber or "filament" refers to a strand of denier less than 15;

A "multi-filament" (or "multifil") refers to simultaneously formed fine denier filaments spun in a bundle of fibers, generally containing at least 3, preferably at least 15-100 fibers and can be several hundred or several thousand;

An "extruded strand" refers to an extrudate formed by passing polymer through a forming-orifice, such as a die;

A "bicomponent fiber" refers to a fiber comprising two polymer components, each in a continuous phase, e.g. side-by-side or sheath/core;

A "bicomponent staple fiber" refers to a fine denier strand which have been formed at, or cut to, staple lengths of generally one to eight inches (2.5 to 20 cm).

[0003] The shapes of these bicomponent fibers, extruded strands and bicomponent staple fibers can be any which is convenient to the producer for the intended end use, e.g., round, trilobal, triangular, dog-boned, flat or hollow. The configuration of these bicomponent fibers or bicomponent staple fibers can be symmetric (e.g., sheath/core or side-by-side) or they can be asymmetric (e.g., a crescent/moon configuration within a fiber having an overall round shape).

[0004] An improved method has now been discovered for making thermoplastic bicomponent fibers by contacting under thermally bonding conditions (a) a first component comprising at least one high performance thermoplastic polymer, and (b) a second component comprising a blend of at least one high density polyethylene (HDPE) and at least one grafted linear ethylene polymer having pendant succinic acid or succinic anhydride groups, said second component forming at least a portion of the fiber's surface, the improvement being that the use of HDPE confers to the resulting fiber superior properties. Indeed, these novel thermoplastic bicomponent fibers have superior stiffness, a relatively low melting or bonding temperature, superior adhesive properties, and superior adhesion of the components within the bicomponent fiber when compared to the same fiber using LLDPE instead of HDPE. The grafted linear ethylene polymer having pendant succinic acid or succinic anhydride groups can be a grafted HDPE or LLDPE, preferably a grafted LLDPE.

[0005] In a further aspect of the invention, there is provided an improved method of bonding high performance natural and/or synthetic fibers such as polyether (e.g., PET or PBT), polyamides (e.g., nylon), cellulotics (e.g., cotton), modified cellulotics (e.g., rayon), wool or the like, with binder fibers and heating the fibrous mixture to thermally bond the binder fiber to the high performance fibers, the improvement comprising providing the superior thermoplastic bicomponent fibers of the present invention used as binder fibers.

[0006] In a further aspect of the invention, there is provided as adhesive polymer blend for fiber forming use as a component in making thermoplastic bicomponent fibers. The polymer blend comprises at least one grafted linear ethylene polymer having pendant succinic acid or succinic anhydride groups and at least one ungrafted linear ethylene polymer. The adhesive polymer blend can be used to prepare bicomponent fibers in accordance with the present invention by contacting the fiber with a water soluble ionic dye, preferably a water soluble cationic dye, in a suitable aqueous medium. The aqueous medium can contain surfactants, if desired, to promote contact.

[0007] In yet another aspect, there is provided a thermoplastic bicomponent fiber characterized by (a) a first component comprising at least one high performance thermoplastic polymer, and (b) a second component comprising a blend of at least one high density polyethylene (HDPE) and at least one grafted linear ethylene

polymer having pendant succinic acid or succinic anhydride groups which have been contacted under thermally bonding conditions.

[0008] The linear ethylene polymer used for grafting can be linear HDPE and/or LLDPE. The density of linear HDPE before grafting can be about 0.94 to 0.97 g/cc, but is typically between about 0.945 and 0.965 g/cc, while that of LLDPE before grafting can be about 0.88 to 0.94 g/cc, but is typically between about 0.91 and 0.94 g/cc. Typically, linear HDPE and LLDPE will have about the same density before and after grafting, but this can vary depending on the particular linear ethylene polymer properties, graft level, grafting conditions and the like. The linear ethylene polymer before grafting has a melt index (MI) measured at 190°C./2.16 kg from about 0.1 to about 1000 grams/10 minutes, but typically less after grafting. For example, linear HDPE with a 25 MI and a 0.955 g/cc density grafted to a level of about 1 weight percent maleic anhydride (MAH) has a MI after grafting of about 16-18 grams/10 minutes. Melt index herein is measured in accordance with ASTM D1238 condition 190°C./2.16 kg (also known as condition "E"). Densities are measured according to ASTM-D-792 and defined as in ASTM-D-1248-84.

[0009] The grafting of succinic acid or succinic anhydride groups may be done by methods described in the art which generally involve reacting maleic acid or maleic anhydride is admixture with heated polymer, generally using a peroxide or free radical initiator to accelerate the grafting. The maleic acid and maleic anhydride compounds are known in these relevant arts as having their olefin unsaturation sites conjugated to the acid groups. Fumaric acid, an isomer of maleic acid which is also conjugated, gives off water and rearranges to form maleic anhydride when heated, and thus is operable in the present invention. Grafting may be effected in the presence of oxygen, air hydroperoxides, or other free radical initiators, or in the essential absence of these materials when the mixture of monomer and polymer is maintained under high shear and heat conditions. A convenient method for producing the graft polymer is extrusion machinery, although Brabender mixers or Banbury mixers, roll mills and the like may also be used for forming the graft polymer. It is preferred to employ a twin-screw devolatilizing extruder (such as a Werner-Pfleiderer twin-screw extruder) wherein maleic acid or maleic anhydride is mixed and reacted with the linear ethylene polymer(s) at molten temperatures to produce and extrude the grafted polymer.

[0010] The anhydride or acid groups of the grafted polymer generally comprise from about 0.001 to about 10 weight percent, preferably from about 0.01 to about 5 weight percent, and especially from 0.1 to about 1 weight percent of the grafted polymer. The grafted polymer is characterized by the presence of pendant succinic acid or anhydride groups along the polymer chain, as opposed to the carboxylic acid groups obtained by the bulk copolymerization of ethylene with an alpha.,.

beta.-ethylenically unsaturated carboxylic acid such as acrylic acid as disclosed in European Patent Application 0 311 860 A2). Grafted linear LLDPE is the preferred grafted linear ethylene polymer.

[0011] The ungrafted HDPE usually shows a density of about 0.94 to 0.97 g/cc, but is typically between about 0.945 and 0.965 g/cc.

[0012] The polyethylene blend preferably contains from about 0.5 to about 99.5 weight percent of grafted linear ethylene polymer, more preferably from about 1 to 50 weight percent grafted linear ethylene polymer, and especially from about 2 to 15 weight percent grafted linear ethylene polymer. The polymer blend can also include conventional additives, such as dyes, pigments, antioxidants, UV stabilizers, spin finishes, and the like and/or relatively minor proportions of other fiber forming polymers which do not significantly alter the melting properties of the blend or the improved hand obtained in fabrics containing fibers employing HDPE as a polymer blend component.

[0013] The LLDPE employed as the grafted linear ethylene polymer component in the thermoplastic bicomponent fiber, comprises at least a minor amount of a C3-C12 olefinically unsaturated alkene, preferably a C4-C8 olefinically unsaturated alkene, and 1-hexene and 1-butene are especially preferred. The alkene may constitute from about 0.5 to about 35 percent by weight of the LLDPE, preferably from about 1 to about 20 weight percent, and most preferably from about 2 to about 15 weight percent.

[0014] The grafted linear ethylene polymer (e.g., grafted linear LLDPE) and the ungrafted linear ethylene polymer (i.e. HDPE) may be blended together prior to extrusion, either by melt blending or dry blending. Dry blending of pellets of the grafted linear ethylene polymer and the ungrafted HDPE prior to extrusion is generally adequate where the melt indices of the blend components are similar, and there will generally be no advantage in melt blending such blend constituents prior to extrusion. However, where melt blending may be desired, as in the case of grafted linear LLDPE and HDPE or dissimilar melt indices, melt blending may be accomplished with conventional blending equipment, such as, for example, mixing extruders, Brabender mixers, Banbury mixers, roll mills and the like.

[0015] The high performance thermoplastic polymer useful as such as the first component of the thermoplastic bicomponent fiber of the present invention can be a polyester (e.g., PET or PBT) or a polyamide (e.g., nylon). The high performance thermoplastic polymer can be used as one component of the bicomponent fiber by contacting it with the ethylene polymer blend under thermally bonding conditions, such as that encountered when coextruding bicomponent fiber using a bicomponent staple fiber die. The high performance polymer can be either component of a sheath/core configuration or it can be either component of a side-by-side configuration. The high performance thermoplastic polymer can be

chosen to provide stiffness in the bicomponent fiber, especially when the grafted linear ethylene polymer is a polymer blend of HDPE blended with grafted LLDPE. Additionally, the high performance thermoplastic polymer used in making the bicomponent fiber of the present invention can be the same polymer as that used for making high performance fiber which is blended with the bicomponent fiber.

[0016] Extrusion of the polymer through a die to form a fiber is effected using convention equipment such as, for example, extruders, gear pumps and the like. It is preferred to employ separate extruders, which feed gear pumps to supply the separate molten polymer streams to the die. The grafted linear ethylene polymer or polymer blend is preferably mixed in a mixing zone of the extruder and/or in a static mixer, for example, upstream of the gear pump in order to obtain a more uniform dispersion of the polymer components.

[0017] Following extrusion through the die, the fiber is taken up in solid form on a godet or another take-up surface. In a bicomponent staple fiber forming process, the fibers are taken up on a godet which draws down the fibers in proportion to the speed of the take-up godet. In the spunbond process, the fibers are collected in a jet, such as, for example, an air gun, and blown onto a take-up surface such as a roller or moving belt. In the melt blown process, air is ejected at the surface of the spinnerette which serves to simultaneously draw down and cool the fibers as they are deposited on a take-up surface in the path of the cooling air. Regardless of the type of melt spinning procedure which is used, it is important that the fibers be partially melt drawn in a molten state, i.e. before solidification occurs. At least some drawdown is necessary in order to orient the polymer molecules for good tenacity. It is not generally sufficient to solidify the fibers without significant extension before take-up, as the fine strands which are formed thereby can hardly be cold drawn, i.e. in a solid state below the melting temperature of the polymer, because of their low tenacity. On the other hand, when the fibers are drawn down in the molten state, the resulting strands can more readily be cold drawn because of the improved tenacity imparted by the melt drawing.

[0018] Melt drawdowns of up to about 1:1000 may be employed depending upon spinnerette die diameter and spinning velocity, preferably from about 1:10 to about 1:200, and especially 1:20 to 1:100.

[0019] Where the bicomponent staple-forming process is employed, it may be desirable to cold draw the strands with conventional drawing equipment, such as, for example, sequential godets operating at differential speeds. The strands may also be heat treated or annealed by employing a heated godet. The strands may further be texturized, such as, for example, by crimping and cutting the strand or strands to form staple. In the spun bonded or air jet processes, cold drawing of the solidified strands and texturizing is effected in the air jet and by impact on the take-up surface, respectively. Sim-

ilar texturizing is effected in the melt blown process by the cooling fluid which is in shear with the molten polymer strands, and which may also randomly delinearize the fibers prior to their solidification.

[0020] The bicomponent fibers so formed by the above-described process also constitute a part of the present invention. The bicomponent fibers are generally fine denier filaments of 15 denier or less down to fractional deniers, preferably in the range of from 1 to 10 denier, although this will depend on the desired properties of the fibers and the specific application in which they are to be used.

[0021] The bicomponent fibers of the present invention have a wide variety of potential applications. For example, the bicomponent fibers may be formed into a batt and heat treated by calendaring on a heated, embossed roller to form a fabric. The batts may also be heat bonded, for example, by infrared light, ultrasound or the like, to obtain a high loft fabric. The fibers may also be employed in conventional textile processing such as carding, sizing, weaving and the like. Woven fabrics made from the bicomponent fibers of the present invention may also be heat treated to alter the properties of the resulting fabric.

[0022] A preferred embodiment of the invention resides in the employment of the bicomponent fibers formed according to the process of the invention in binder fiber applications with high performance natural and/or synthetic fibers such as, for example, polyamides, polyesters, silk, cellulosics (e.g. cotton), wool, modified cellulosics such as rayon and rayon acetate, and the like. The bicomponent fibers of the present invention find particular advantage as binder fibers owing to their adhesion to performance fibers and better balance of global properties thereof, especially superior stiffness, which is enhanced by the presence of the acid groups in the grafted ethylene polymer component and the relatively lower melting temperature or range of the grafted ethylene polymer component relative to the performance fiber. The relative proportions of the binder fiber of the present invention employed in admixture with performance fibers in a fiber blend will depend on the desired application and capabilities of the resulting fiber mixture and/or fabric obtained thereby. It is preferred to employ from about 5 to about 95 parts by weight of the binder fiber per 100 parts by weight of the binder fiber/performance fiber mixture, more preferably from about 5 to about 50 parts by weight binder fiber, and especially 5 to 15 parts by weight binder fiber.

[0023] In preparing non-woven fabrics from the bicomponent binder fiber/performance fiber blend of the invention, there are several important considerations. Where the binder fibers are in staple form, there should be no fusing of the fibers when they are cut into staple, and the crimp imparted to the binder fibers should be sufficient for blending with the performance fibers to obtain good distribution of the fibers.

[0024] The ability of the component comprising at

least one grafted linear ethylene polymer having pendant succinic acid or anhydride groups to adhere to the other component of at least one high performance thermoplastic polymer is an important consideration in cutting of bicomponent staple fiber. When bicomponent staple fiber is cut and one of the components (e.g., the core of a bicomponent fiber) protrudes from the cut edge, the fiber will create an irritation when worn next to the skin. The irritation is especially pronounced when the core component is a high performance thermoplastic such as PET. When ungrafted linear ethylene polymer and PET are made, respectively, into a sheath/core bicomponent fiber and cut into short staple fiber, the core of PET protrudes beyond the cut edge. The enhanced adhesion of the grafted linear ethylene polymer component to the PET component used in making the thermoplastic bicomponent fiber of the present invention reduces PET protrusion beyond the fiber after cutting and thus enables fabrics and fiber blends to be made which can be more comfortably worn next to the skin.

[0025] The ability of the bicomponent binder fibers to adhere to the performance fibers is another important consideration. Adhesion and dyeability can generally be controlled by varying the acid content of the binder fiber, either by the level of graft of maleic acid or anhydride in the grafted linear ethylene polymer, or by the proportion of the grafted linear ethylene polymer blended with the ungrafted linear ethylene polymer in the bicomponent binder fibers. In typical non-woven fabrics obtained by thermally bonding the performance fibers with a bicomponent binder fiber, the ability of the binder fibers to bond together the performance fibers depends largely on the thermal bonding of the performance fibers together by the binder fibers. In typical prior art non-woven fabrics employing binder fibers, the binder fiber thermally bonds performance fibers together by at least partially melting to form globules or beads which encapsulate the performance fibers. The binder fibers of the present invention enhance the non-woven fabric by providing great adhesion of the binder fiber to the performance fiber. Employing the binder fibers of the present invention, it is also possible to obtain thermal bonding of the binder fiber to a performance fiber by partial melting and contact adhesion in which the bicomponent binder fibers largely retain their fibrous form, and the resulting non-woven fabric is characterized by a reduced number of globules or beads formed by the melting of the lower melting component of the bicomponent binder fibers.

[0026] It is also important for one component of the bicomponent binder fiber to have a relatively broad melting point range or thermal bonding window, particular where hot calendaring is employed to obtain a thermal bonding of a non-woven or woven fabric. A good indication of melting point range or thermal bonding window is the difference between the Vicat softening point and the peak melting point determined by differential scanning calorimetry (DSC). Narrow melting point ranges

present a difficult target for process bonding equipment such as a calendar roll, and even slight variations in the temperature of bonding equipment can result in an insufficient bond to be formed between the bicomponent binder fibers and the performance fibers. If too low a temperature is employed, the bicomponent binder fibers will not sufficiently fuse, whereas when too high a temperature is employed, one component of the bicomponent binder fiber may completely melt and run right out of the performance fiber batt. Thus, a broad melting point range is desired in order that partial fusion of one component of the bicomponent binder fiber material can be achieved without a complete melting. A melting point range of at least 7.5.degree. C. is desired for proper thermal bonding, and preferably a sufficiently broad melting point range that a minimum 10.degree. C. bonding window is obtained.

[0027] Another important characteristic of bicomponent binder fibers is that when they are melted in equipment such as a calendar roll, one of the components will have a sufficient melt viscosity to be retained in the fiber matrix and not readily flow therefrom. An important advantage of the bicomponent binder fibers of the present invention is that one component has generally higher melt viscosity than fibers consisting of ungrafted LLDPE. In addition to using a calendar roll, bonding of the present binder fibers can also be obtained using other bonding techniques, e.g. with hot air, infrared heaters, and the like.

[0028] The thermoplastic bicomponent fibers of the invention can be dyed by contacting them with a water soluble ionic dye, preferably a water soluble cationic dye, in a suitable aqueous medium. The aqueous medium can contain surfactants, if desired, to promote contact.

Claims

1. Thermoplastic bicomponent fiber consisting of (a) a first component which consists of polyethylene terephthalate, polybutylene terephthalate, or nylon, and (b) a second component which is olefinic and which forms at least a portion of the fiber's surface, wherein the second component (b) comprises a blend of at least one grafted linear high density polyethylene or linear low density polyethylene having pendant succinic acid or anhydride groups with a high density polyethylene.



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EUROPEAN SEARCH REPORT

Application Number
EP 01 43 0010

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 372 885 A (TABOR RICKY L ET AL) 13 December 1994 (1994-12-13) * claims 1-4 * -----	1	D01F8/06 D01F8/12 D01F8/14
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			D01F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		16 August 2001	Tarrida Torrell, J
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p>			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 43 0010

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-08-2001

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