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(54) **Tape yarn of polyester/polypropylene resin blend and carpet backing woven therefrom.**

(57) Tape yarns suitable for weaving, particularly into primary carpet backing fabrics for tufted carpet tiles and automotive carpets, are composed of polyester/polyolefin resin blends and prepared by slitting and drawing films extruded from such blends.

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TAPE YARN OF POLYESTER/POLYPROPYLENE RESIN BLEND AND CARPET BACKING WOVEN THEREFROM

Field of the Invention

This invention relates to tape yarns suitable for weaving, comprising a resin blend of polyester and propylene polymer components, and carpet backings woven from such yarns. The invention also relates to a resin blend suitable for manufacture of tape yarns and a process for producing the yarns.

Background of the Invention

Manufacture of tufted carpets normally involves tufting a primary backing followed by washing, dying and drying the tufted backing and then subjecting the same to a finishing operation.

Tufting usually is accomplished by inserting reciprocating needles threaded with yarn through the primary backing to form tufts or loops of yarn. Loopers or hooks, typically working in timed relationship with the needles, are located such that the loopers are positioned just above the needle eye when the needles are at an extreme point in their stroke through the backing fabric. When the needles reach that point, yarn is picked up from the needles by the loopers and held briefly. Loops or tufts of yarn result from passage of the needles back through the primary backing. This process typically is repeated as the loops move away from the loopers due to advancement of the backing through the needling apparatus. If desired, the loops can be cut to form a cut pile, for example by using a looper and knife combination in the tufting process. Alternatively, the loops can remain uncut.

Primary backings for tufted carpets are typically woven or nonwoven fabrics made of one or more natural or synthetic fibers or yarns such as jute, polypropylene, polyethylene, polyamides, polyesters and rayon. Films of synthetic materials, such as polypropylene, polyethylene and ethylene-propylene copolymers, also can be used to form a primary backing.

The tufts of yarn inserted in the tufting process are usually held in place by untwisting of the yarns as well as shrinkage of the backing. In the finishing operation, the back side or stitched surface of the backing usually is coated with an adhesive, such as a natural or synthetic rubber or resin latex or emulsion or a hot melt adhesive, to enhance locking or anchoring of tufts to the backing. Use of such adhesives also improves dimensional stability of the tufted carpet, resulting in more durable carpets of improved skid and slip resistance. The tufted carpet often is further stabilized in the finishing operation by laminating a secondary backing, for example a thermoplastic film or a woven or nonwoven fabric made from polypropylene, polyethylene or ethylene-propylene copolymer or natural fibers, such as jute, to the primary backing. The adhesive used in the finishing operation bonds the primary backing to the secondary backing.

Carpet backings woven from polypropylene yarns are well known and widely used commercially. An example of such a backing is disclosed in U.S. Patent 3,110,905 to Rhodes, issued November 19, 1963, which is directed to backings woven from yarns of flat, rectangular, cross-section of thermoplastic resins, including polypropylene, for tufted carpets. Manufacture of such yarns and use of the same to manufacture woven carpet backings is disclosed in U.S. 3,503,106, issued March 31, 1970, to Port et al., directed to extrusion of thermoplastic resins to form a film-like web, orienting the film by stretching, slitting the oriented films into tape or ribbon-like yarns, folding the tapes, calendering the folded tapes and then feeding the tapes to a loom for weaving. Such flat, rectangular yarns are often referred to as tape or ribbon yarns.

For some end uses, backings woven from polypropylene tape yarns have found limited use. In automotive carpets, woven polypropylene backings have limited utility because molding of the carpet to automobile interior surfaces often is conducted above the melting point of polypropylene or at temperatures high enough to cause stretching of polypropylene yarns and loss of dimensional stability. Woven polypropylene backings are not favored for use in carpet tile for similar reasons. When carpet tiles are adhered to surfaces using hot melt adhesives, heating to activate such adhesives often is performed at temperatures high enough to cause stretching of the backing yarns such that dimensional stability is sacrificed.

For automotive carpets, carpet tiles and other carpet structures to be exposed to temperatures above the melting point of polypropylene or high enough to cause stretching of polypropylene yarns, backings woven from other materials are known. However, higher melting materials pose other difficulties. Woven polyester backings for automotive carpets and carpet tile have been proposed. Polyester yarns can

withstand temperatures higher than polypropylene yarns without substantial loss of dimensional stability; however, backings woven from polyester tape yarns are poorly suited for manufacture of tufted carpets because the yarns are brittle and abrasive such that substantial deflection and breakage of both needles and yarns occurs during tufting, resulting in poor carpet quality.

U.S. Patent No. 4,556,602, issued December 3, 1986, discloses polypropylene backings for carpets and carpet tiles having woven reinforcing yarns less prone to stretching than polypropylene, preferably of nylon, polyester or fiberglass, in the warp direction. While dimensional stability of such carpets is improved relative to those prepared from polypropylene backings, other things being equal, incorporation of warp reinforcing yarns adds cost and complexity to manufacture of backings and the reinforced backings may contain enough polypropylene yarns to lead to difficulties in high temperature processing.

Nonwoven polyester carpet backings also have been proposed and are commercially available. Such backings overcome the high temperature limitations of polypropylene backings. However, their random orientation of fibers within the nonwoven web, while reducing tufting difficulties experienced with woven polyester tape yarn backings, give the backings reduced dimensional stability relative to woven backings including those of polypropylene.

It will be appreciated from the above that it would be desirable to provide yarns and carpet backings woven therefrom wherein dimensional stability, high temperature processability and tuftability by conventional needling techniques are adequate to overcome the above described difficulties. It is an object of this invention to provide improved tape yarns suitable for manufacture of woven carpet backings for tufted carpets, including carpet tiles and automotive carpet. A further object of the invention is to provide such carpet backings and carpet structures containing the backings. Another object of the invention is to provide a resinous composition suitable for use in manufacture of such improved yarns and a process for manufacture of slit-film yarns from the resins. Other objects of the invention will be apparent to persons skilled in the art from the following description and claims.

I have now found that the objects of this invention can be attained by providing tape yarns of a polyester resin component and a substantially crystalline propylene polymer component in which proportions and melt rheology of the components are such that extruded films of good strength in the molten state and of sufficiently low stiffness, abrasion and brittleness for preparation of tape yarns can be obtained and in which the beneficial properties of the polyester component in terms of yarn strength, stiffness and dimensional stability are retained while sufficient splitting characteristics for good needle penetration in tufting operations also is achieved though not to such a degree that splitting of yarns weakens carpet backings woven from the yarns. The polyester and propylene polymer components of the invented yarns are incompatible, being present in the tape yarns as a two-phase system, and facilitate splitting of the yarns during needling. During processing of the resin into tape yarns, the polyester component, being of intermediate intrinsic viscosity and relatively low melt strength, is, in effect, supported in the melt by the relatively higher melt viscosity, molten propylene polymer component such that substantially uniform film thickness and good film strength are achieved. Advantageously, the yarns can be woven by conventional techniques into fabrics, including carpet backing fabrics of good strength and dimensional stability capable of withstanding higher processing temperatures than woven polypropylene backings without substantial loss of properties. Such carpet backing fabrics are easily penetrated by needles used in conventional carpet manufacturing processes. Accordingly, the backings are well suited for use in a variety of carpet structures and particularly useful in manufacture of carpet structures for carpet tile and automotive applications.

The Prior Art

As discussed above, U.S. Patent No. 4,556,602 issued December 3, 1985, is directed to improved woven polypropylene backings for use in carpets and carpet tiles in which reinforcing yarns are woven into the warp. While the patent recognizes problems of dimensional stability in woven polypropylene backings for carpet tiles, the solution according to the patent, incorporation of reinforcing yarns into such backings, does not suggest the present invention wherein yarns of a multi-phase resin are used to prepare backing structures.

Other patents and publications which may be of interest in connection with the present invention in disclosing various blends of polyester and polypropylene polymer resin components for various purposes are discussed below. Although such blends and various utilities therefor are disclosed, the problem of improving tuftability of polyester yarns for carpet backing structures to be used in applications, such as carpet tile and automotive carpets, having substantial requirements as to dimensional stability, high

temperature processability and tuftability by needling are not addressed.

U.S. 3,579,609, issued May 18, 1971, to Sevenich, is directed to improving flex resistance of poly(ethylene terephthalate) films used as packaging and magnetic recording tapes by blending minor amounts of fusible, heat stable polymers of mono-alpha olefins with the poly(ethylene terephthalate). According to the patent, 2-40 weight percent olefin polymer can be used although there is no advantage to adding more than about 15 weight percent. Polyethylene, polypropylene, polybutylene, poly-4-methyl pentene and polytetramethylene oxides are said to be most effective for improving flexibility in poly(ethylene terephthalate). It also is reported that the improved film appears to consist of elongated globules 0.1-5 microns thick by 0.25-6.5 microns wide of polyethylene imbedded in the polyester and that the resins are incompatible.

U.S. 3,604,196, issued September 14, 1971, to Prevorsek et al., is directed to fibers of up to 4 denier for use in making apparel fabrics. The fibers are composed of blends of incompatible polymers in which one or more polymer species is dispersed in a matrix of another species, specifically disclosed polymer blends being 50/25/25 and 40/30/30 polycaproamide/poly(ethylene terephthalate) /polypropylene, 70/30 polycaproamide/poly(ethylene terephthalate), and 35/65 polycaproamide/polypropylene. Yarns according to the patent exhibit irregular crimp and consist of a multitude of fine fibers of varying denier averaging 4 or less. The yarns are said to be suitable for stretch-type apparel. Other disclosed utilities are in draperies, upholstery, carpet, insulation and linen-like textiles. The fine fibers are produced by subjecting a splittable, elongated structure composed of a blend of the incompatible polymers to a rolling pressure down the length against one crosswise direction of the elongated structure maintained in semiamorphous state by maintaining temperature below the glass transition temperature of at least one of the blend components, and subjecting the semiamorphous structure to a transverse force gradient, such as by twisting, flexing, rubbing or tearing, to split the structure longitudinally into fine fibers.

U.S. 3,705,074 issued December 5, 1972, to Lamb et al., is directed to high bulk, soft yarns from monofilaments for use in apparel fabrics and discloses longitudinally oriented film or monofil consisting essentially of, and prepared by extruding, 50-90 percent fiber forming polymer selected from polyamides, polyesters and polyolefins or a mixture thereof and 5-50 percent polyester having a molecular weight too low for fiber strength. The low molecular weight polyester component has a reduced viscosity in metecrasol of 0.1-0.35 dl/g.

U.S. 3,707,837, issued January 2, 1973, to Gibbon is directed to a process for fibrillating fibrillatable tape at throughputs above 500 feet per minute to produce yarns of relatively soft handle, high tenacity, good cover, desirable luster and excellent printability having utility in knitting, weaving and tufting. The disclosed process, said to be applicable to any fibrillatable tape, comprises subjecting a travelling, fibrillatable tape under tension of about 0.05-0.2 grams per denier to the action of at least four fluid twisting means, such as a fluid jet, wherein the direction of twist imparted to the tape is completely reversed between adjacent twisting means. Prior to twisting, the tape is hot drawn to a draw ratio of about 3.3-4.2 at about 80-140 °C, then subjected to a temperature of about 120-230 °C for about 0.01-0.2 seconds, preferably to achieve a draw ratio of about 4-5.5. Fibrillation of tapes by other means, including contacting with a grooved roller, passage over a stationary brush or similar shredding means, piercing in a plurality of points and passing through a zone of high turbulence also is disclosed.

Preferred tapes in the process of Gibbon are said to comprise poly(ethylene terephthalate), and blends thereof with about 0.1-25 percent by weight incompatible polymer, based on weight of the poly(ethylene terephthalate), are disclosed. Preferred incompatible polymers are said to be polypropylene and polyethylene with the former being most preferred. The polypropylene must be finely dispersed throughout the poly(ethylene terephthalate) according to Gibbon, such dispersion being facilitated by use of poly(ethylene terephthalate) and polypropylene of about equal viscosities. The patent discloses that good dispersion is achieved by mixing and extruding at high temperature through a slit die poly(ethylene terephthalate) having intrinsic viscosity of about 0.45-0.75 containing about 0.5-5 percent polypropylene, by weight of poly(ethylene terephthalate), having a melt flow rate, according to ASTM D-1238 62T, Condition B or L, of about 8-22, at an extrusion temperature of about 280-300 °C via a pack that imposes a shear force of about 60-150 reciprocal seconds for about 1-2 seconds.

Canadian Patent No. 960012, issued December 31, 1974, to Gibbon discloses fibrillating fibrillatable, 0.002-0.005 inch thick tapes of at least 90 weight percent poly(ethylene terephthalate) that have been drawn as described in the above-discussed U.S. patent to Gibbon. Blends of poly(ethylene terephthalate) with about 0.5-5 percent polypropylene, by weight of poly(ethylene terephthalate), wherein the poly(ethylene terephthalate) intrinsic viscosity is about 0.40-0.80 and polypropylene melt flow index, according to ASTM D-1238 62T Condition E or L, is about 8-22, and extrusion of such a blend as in the U.S. patent to Gibbon are disclosed. Advantages and utility of yarns also are as disclosed in the U.S. patent to Gibbon. Blends of

poly(ethylene terephthalate) and polypropylene as described in the U.S. patent to Gibbon also are disclosed in U.S. 4,036,003, issued July 19, 1977, to Lowder et al.; U.S. 4,123,490, issued October 31, 1978, to Gibbon; and U.S. 4,179,875, issued December 25, 1979, to Gibbon, all of which are directed to fibrillated tapes for use as sewing threads.

U.S. 4,368,295, issued January 11, 1983, to Newton et al., discloses oriented films, for use as paper substitutes, carbon paper and typewriter ribbon bases, in high speed printing applications, as textile threads, magnetic recording tape, packaging, laminates and identity cards, comprising linear polyester and 0.5-100 percent, by weight of polyester, of at least one olefin polymer (e.g., polyethylene, polypropylene, poly-4-methylpentene, ethylenepropylene copolymers) and 0.05-50 percent, by weight of the olefin polymer, of a carboxylated polyolefin. According to the patent, the carboxylated polyolefin is used to improve dispersion of the olefin polymer in the polyester, thereby avoiding streaks of clear regions that occur in otherwise opaque or translucent, oriented films prepared from linear polyester/olefin polymer blends lacking the carboxylated component.

U.S. 4,547,420, issued October 15, 1985, to Krueger et al., is directed to bicomponent fibers, for use in making nonwoven, fibrous webs, comprising first and second polymer components of generally similar melt viscosities wherein the first component is at least partially amorphous, but crystallizable, at a temperature below the melting point of the second component. Representative polymer combinations are said to include poly(ethylene terephthalate)/polypropylene and poly(ethylene terephthalate)/polyamide. Proportions of the components range from 40-60 to 60-40 volume percent.

Bataille et al., Journal of Elastomers and Plastics, 18, October, 1986, pages 228-233 reports results of a study of mechanical property and water permeability testing of compression molded placques of blends of poly(ethylene terephthalate) and polypropylene in various proportions, noting that both resins are useful as geotextiles and that 80/20 blends of poly(ethylene terephthalate) and polypropylene are used in soft drink bottles and concluding that specific compositions may be attractive in selected applications such as geotextiles. The authors report, with respect to mechanical properties, "strong negative deviations ... from the rule of mixtures-behavior, suggesting that the two polymers are poorly (weakly) bonded at domain contacts" and, with respect to water permeation, a more complicated diffusion path in the two component system.

While these patents and the publication describe various blends containing a polyester component and a polyolefin component, including propylene polymers, neither the poly(ethylene terephthalate)/propylene polymer blends according to this invention nor tape yarns comprising the same is taught or suggested, nor is utility of such yarns in woven carpet backings of good dimensional stability, high temperature processability and tuftability by needling.

Summary of the Invention

Briefly, the yarns of this invention are characterized by substantially flat, rectangular cross-section and comprise a resinous blend comprising a poly(ethylene terephthalate) component having dispersed therein about 17 to about 43 percent, by weight of the poly(ethylene terephthalate component, of a substantially crystalline propylene polymer component.

Such yarns are produced by a process comprising (a) forming a molten, intimate mixture comprising a poly(ethylene terephthalate) component having intrinsic viscosity of about 0.7 to about 1.0 dl/g in o-chlorophenol, according to ASTM D-2857, and about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component having a melt flow rate of about 2 to about 18 g/10 minutes, according to ASTM D-1238 Condition L, such mixture being substantially free of water; (b) extruding the molten mixture through a film die onto a chill roll to obtain a quenched film of substantially uniform thickness; (c) slitting the quenched film along its length into a plurality of tapes; and (d) drawing the tapes lengthwise at a draw ratio of about 4:1 to about 5.5:1.

Also provided according to the present invention are woven carpet backing fabrics for tufted carpet structures and, in particular, woven primary backing fabrics well suited for use in tufted carpet structures for carpet tile and automotive carpets. The carpet backing fabrics comprise woven warp and fill yarns, at least one of which comprise yarns of substantially flat, rectangular cross-section comprising a resinous blend of components comprising a poly(ethylene terephthalate) component having dispersed therein about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component.

In a further embodiment, this invention provides a resin blend comprising a poly(ethylene terephthalate)

component having intrinsic viscosity of about 0.7 to about 1.0 dl/g in o-chlorophenol according to ASTM D-2857 and about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component having a melt flow rate of about 2 to about 18 g/10 minutes according to ASTM D-1238 Condition L.

Detailed Description of the Invention

In greater detail, the yarns of this invention are characterized by substantially flat, rectangular cross-section of substantially uniform width and thickness along the length of the yarn. The yarns are composed primarily of a poly(ethylene terephthalate) component and also contain a minor amount of a substantially crystalline propylene component which is effective to allow the yarns to be easily penetrated by tufting needles used in carpet manufacture without excessive splitting and fibrillation and without substantial loss of desirable yarn properties, such as stiffness and dimensional stability, imparted by the poly(ethylene terephthalate) component.

The poly(ethylene terephthalate) and propylene polymers are immiscible, as indicated by thermal analysis showing two discrete melting point peaks, and are believed to be present in the yarns in the form of a matrix or continuous phase of the poly(ethylene terephthalate) component having a discontinuous phase of the propylene polymer component finely and substantially uniformly distributed therethrough.

The poly(ethylene terephthalate) component used in preparing the invented yarns is an intermediate intrinsic viscosity resin of the type commonly used in packaging and liquid container applications. The poly-(ethylene terephthalate) component preferably is a homopolymer poly(ethylene terephthalate) although poly-(ethylene terephthalate)-dominated copolyesters containing minor amounts of copolymerized acid or glycol components or blends with other polyesters can be utilized provided that the copolyesters or blends exhibit suitable intrinsic viscosities and yarn properties. The poly(ethylene terephthalate) component can be prepared by known techniques. Commonly, terephthalic acid or a derivative thereof is esterified or trans-esterified by reaction with ethylene glycol. Blends of virgin poly(ethylene terephthalate) component with recycled resin from the invented process, e.g. edge trim, or regrind from poly(ethylene terephthalate) liquid containers, e.g. soft drink bottles, also can be used. Propylene polymer content of recycled edge trim and intrinsic viscosity losses in the poly(ethylene terephthalate) component thereof as well as in bottle regrind resin must be accounted for in selecting the amount of recycle or regrind to be used.

Suitably, intrinsic viscosity of the poly(ethylene terephthalate) component ranges from about 0.7 to 1 dl/g in o-chlorophenol, determined according to ASTM D-2857. Higher intrinsic viscosity poly(ethylene terephthalate) resins are more difficult to process by extrusion and extruded films of such resins are less tractable than films of lower intrinsic viscosity resins such that slitting thereof into tapes is difficult. Poly-(ethylene terephthalates) having intrinsic viscosity below about 0.7 dl/g are not suitable because they provide insufficient strength to yarns prepared therefrom for carpet backing applications. Further, hydrolysis of such resins during processing lowers molecular weight thereof with accompanying processing difficulties and losses in final product strength. Intrinsic viscosity of the poly(ethylene terephthalate) component used in preparation of the invented yarns can decrease by up to about 0.15 dl/g when processed as in the invented process. Preferably, the poly(ethylene terephthalate) component from which the invented yarns are prepared have intrinsic viscosites of about 0.75 to about 0.85 dl/g in o-chlorophenol according to ASTM D-2857, as the same exhibit deisrable melt processibility for film extrusion and tape manufacture according to the present invention, and are of high enough intrinsic viscosity to withstand some loss of molecular weight strength during processing such that yarns prepared from such resins in combination with effective amounts of propylene polymer component exhibit desirable yarn properties, including tensile strength and elongation.

Suitable poly(ethylene terephthalates) are commercially available. Examples include intermediate intrinsic viscosity grade polyesters available from The Goodyear Tire and Rubber Company under the name Cleartuf Polyester.

The propylene polymer component used in preparing the invented yarns is a substantially crystalline propylene homopolymer or copolymer of propylene with minor amounts, e.g., up to about 30 mole %, of one or more copolymerizable alpha-olefins such as ethylene, butene-1 and pentene-1. Such propylene polymers are commercially available and typically prepared by polymerizing propylene or propylene and comonomer(s) in the presence of heterogeneous catalysts comprising a transition metal halide component, e.g., a supported or unsupported titanium chloride composition, and an organometallic component, e.g. an aluminum alkyl or alkyl aluminum chloride, at elevated temperatures and pressures and often in the

presence of agents for regulating molecular weight, for example, hydrogen. Electron donors often are used in such polymerization to reduce levels of amorphous propylene polymer produced during polymerization. A preferred propylene polymer component according to the present invention is substantially crystalline homopolymer polypropylene.

The propylene polymer component has a melt flow rate according to ASTM D-1238 Condition L of about 2 to about 18 g/10 minutes. The component provides melt strength to the poly(ethylene terephthalate) component used according to the present invention at temperatures and other condi tions employed in preparation of yarns according to this invention, thereby facilitating extrusion of films of substantially uniform thickness and substantially lacking in thin spots from the resinous blends. Propylene polymer components of greater melt viscosity, e.g. having melt flow rates below about 2 g/10 minutes, are more difficult to disperse in the poly(ethylene terephthalate) component and give extruded films having a rough and grainy texture poorly suited for use according to the invention. Degradation of the propylene polymer component during processing may result in melt flow rate increases to up to about two times that of the starting material. Low melt viscosity propylene polymer components, e.g. those with melt flow rates above about 18 g/10 minutes, provide insufficient melt strength to the resinous blend during film extrusion and result in weak films with thin spots and non-uniform thickness.

Preferably, the propylene polymer component has melt flow rate of about 3 to about 14 g/10 minutes according to ASTM D-1238 Condition L in order to attain good dispersion in the poly(ethylene terephthalate) component and facilitate extrusion of the blends into films of substantially uniform thickness, best results being achieved at about 3.5 to about 5 g/10 minutes.

The invented yarns are prepared from a blend of components comprising poly(ethylene terephthalate) and propylene polymer components as described above in amounts such that about 17 to about 43 percent propylene polymer component is present by weight of the poly(ethylene terephthalate) component. Greater amounts of the propylene polymer component in the blends yield tape yarns that lack strength, fibrillate excessively and are prone to dusting, making such yarns unsatisfactory for use in woven carpet backing structures. Below about 17 weight percent propylene polymer component, yarns have inadequate needle penetrability for tufting.

Preferably, to attain good processibility and yarns of suitable strength that can be woven into fabrics easily penetrated by needles during tufting operations without excessive fibrillation, the resin blends used according to this invention contain about 20 to about 35 percent propylene polymer component by weight of the poly(ethylene terephthalate) component. More preferably about 25 to about 33 weight percent propylene polymer component is present.

Such resin blends can contain various additives and agents of the type commonly included in the individual resin components thereof. Examples include antioxidants, stabilizers, pigments, delusterants, etc.

The invented resin blends, comprising poly(ethylene terephthalate) and propylene polymer components as described above wherein about 17 to about 43 percent propylene polymer component, by weight of the poly(ethylene terephthalate) component, is present, are prepared by combining the resin components. Melt blending of the components, for example in an extruder, typically provides more uniform dispersion of the propylene polymer component in the blend than does dry blending. Dry blending prior to melt compounding may facilitate the latter and yield a more uniform blend.

According to the invention, slit-film yarns suitable for weaving, and particularly well suited for use in manufacture of woven backing fabrics for carpets, are prepared by a process comprising (a) forming a molten, intimate mixture comprising a poly(ethylene terephthalate) component having intrinsic viscosity of about 0.7 to about 1.0 dl/g in o-chlorophenol according to ASTM D-2857 and about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component having a melt flow rate of about 2 to about 18 g/10 minutes according to ASTM D-1238 Condition L, such mixture being substantially free of water; (b) extruding the molten mixture through a film die onto a chill roll to obtain a quenched film of substantially uniform thickness; (c) slitting the quenched film along its length into a plurality of tapes; and (d) drawing the tapes at a draw ratio of about 4:1 to about 5.5:1. Preferably, to reduce shrinkage of the yarns to levels suited for tufted carpet tile and automotive carpet backing structures, the drawn tapes are annealed.

The poly(ethylene terephthalate) and propylene polymer components used in the invented process are combined to form a mixture substantially free of water in order to avoid hydrolysis of the poly(ethylene terephthalate) component during processing and attendant loss of molecular weight and properties. Effects of absorbed water on poly(ethylene terephthalate) and recommended drying procedures and conditions therefor are described in detail in "Goodyear Cleartuf Polyester Product Manual" issued by The Goodyear Tire and Rubber Company. As discussed therein, drying can be conducted in vacuum ovens, double cone rotary vacuum dryers, fluidized bed dryers, hopper dryers and dry air circulating or dehumidifying ovens,

with drying rate depending on initial moisture content of the poly(ethylene terephthalate), drying temperature and degree of vacuum or air circulation rate in the equipment. Recommended drying temperatures set forth therein for air drying are about 150-180 ° C with an air flow rate of at least 1 $m^3/s/kg/hr$ using air with a dew point of -28 ° C.

Water content of the mixture of poly(ethylene terephthalate) and propylene polymer components used to manufacture yarns according to the present invention preferably is about 50 ppm or less. The poly(ethylene terephthalate) component can be dried in the absence of the propylene polymer component, preferably at about 148 to about 177 ° C for about 3 to about 5 hours, or in the presence of the propylene polymer component, preferably at about 120 to about 140 ° C for about 10 to about 15 hours, in either case using circulating dry air. Typically, the undried propylene polymer component in the amounts used according to the invented process contributes up to about 20 ppm water. Accordingly, when the poly(ethylene terephthalate) component is dried in the absence of the propylene polymer component, it preferably is dried to below about 50 ppm water, e.g., about 30-40 ppm, so that separate drying of the propylene polymer component is unnecessary.

After drying, the dried poly(ethylene terephthalate) component or blend thereof with propylene polymer component is introduced into the barrel of an extruder without substantial contact with the atmosphere in order to avoid absorption of water by the hygroscopic poly(ethylene terephthalate) component. This is conveniently accomplished by locating a suitable outlet from the drying equipment, such as a dryer hopper, in direct communication with a feed port of the extruder. If it is desired to feed the propylene polymer component to the extruder separate from the dried poly(ethylene terephthalate) component, separate metering devices for the resins can be used.

The poly(ethylene terephthalate) and propylene polymer components are fed to the extruder barrel and mixed and worked therein by the action of a revolving screw conveyor within the barrel to obtain a molten, intimate mixture of the resin components. Additives can be metered into the barrel with either or both of the components or added separately if desired.

Standard screw designs of the type conventionally used in extrusion of polyester or polypropylene can be used in the invented process, with the former type being preferred to obtain higher throughputs through the extruder. Most suitably, a polyester-type screw that is cored for circulation of water to cool the feed section thereof and with a suitable mixing head located at the end of the metering section is employed. An example of such a screw is a 30:1 length to diameter Davis-Standard barrier-flight polyester screw.

Mixing and working of resin in the extruder barrel is conducted under conditions effective to melt the poly(ethylene terephthalate) and propylene polymer components without substantial degradation and to obtain a substantially uniform mixture of the molten components. Preferred barrel temperature profile is a flat profile with all sections of the barrel set at about 275 ° C to about 300 ° C, although lowering of a first zone temperature, e.g., by about 10 ° C to about 20 ° C, also can be used with good results. Temperatures above about 300 ° C are avoided to minimize degradation of the resin components.

The molten, intimate mixture of poly(ethylene terephthalate) and propylene polymer components is extruded through a film die associated with an outlet of the extruder barrel. Such dies are well known and generally comprise an inlet communicating with the extruder barrel outlet, and a channel for flow of molten resin to a die gap defined by die lips. A suitable die is a standard coat-hanger die of the type widely used in film extrusion. A relatively narrow die gap preferably is used to ensure substantially uniform thickness of the molten, resinous blend issuing as a film from the die. Preferably the gap is about 6 to about 20 mils. The die is heated to maintain the resinous blend in molten condition during passage therethrough. Preferably, die temperature is about 270 ° C to about 300 ° C.

The molten film extruded from the die is cooled to obtain a quenched film of substantially uniform thickness. In view of the relatively low melt strength of the molten extrudate issuing from the die, cooling is preferably accomplished by contacting the extruded film with a cooled chill roll located near the die outlet. Preferably, the gap between the die gap and the chill roll is one-half inch or less in order to minimize formation of thin spots. The chill roll is cooled sufficiently to quench the extruded, molten film. Conveniently, the roll is cooled by circulating cooling water, e.g., at about 60-80 ° C, therethrough.

The quenched film is slit along its length into a plurality of tapes. Most conveniently, the film is passed continuously over a series of cutting edges although other techniques such as slitting with lasers can be employed. Due to stiffness of the quenched film, steel cutting edges of the type conventionally used in slitting polypropylene film into tapes are not preferred because use thereof often results in tapes having rough edges or edge defects which can lead to tape breakage during subsequent drawing of tapes. Blades of harder composition or surface are preferred, good results being obtained with tungsten carbide, ceramic or titanium carbide-coated steel blades.

Slitting of the quenched film into tapes is facilitated by maintaining the film under mild tension during

slitting, for example by adjusting speed of roll pairs used to feed the film to and remove the slit tapes from the slitting apparatus and locating such rolls in close proximity thereto. The quenched film is slit into tapes of desired width by adjusting the spacing between the cutting edges. In manufacture of yarns for use in woven carpet backing fabrics, slit film widths preferably range from about 60 to about 500 mils.

The slit tapes are subsequently drawn lengthwise at a draw ratio of about 4 to about 5.5 to orient the tapes and increase strength and tenacity thereof in the lengthwise direction. Drawing is accomplished by stretching the tapes heated to a temperature above the glass transition temperature of the poly(ethylene terephthalate) component to soften the tapes and permit orientation of the polymer molecules. Preferably, temperatures of about 75° C to about 110° C are employed to facilitate stretching without breakage of tapes. Conveniently, stretching is conducted by passing the slit tapes through a heating zone maintained at the appropriate temperature from feed rolls to takeup rolls with the latter rotating faster than the former to provide the desired degree of stretching. The heating zone can be an oven, a heated surface with which the tapes are contacted or other suitable means. Stretching of tapes in contact with a heated surface is preferred because the surface tends to support the softened tapes thereby minimizing curling which can occur if the tapes are heated in an unsupported state. Average residence time of the tapes in contact with such a heated surface most preferably is about one-half to about two seconds.

Drawing can be conducted in one or more steps to achieve a final draw ratio of about 4:1 to about 5.5:1. Preferably, drawing at a draw ratio of about 4.5:1 to about 5:1 is completed at about 85 to about 100° C in a single step to attain yarns having tenacities of about 3.4 to about 4.5 g/denier with elongations of about 25 to about 45 percent. For yarns to be used in woven carpet backing fabrics, drawn tapes having widths of about 30 to about 500 mils and thicknesses of about 1.5 to about 3.5 mils are preferred.

Preferably, and particularly in the case of slit-film yarns to be used to prepare woven fabrics for use as primary backings for tufted automotive carpets and carpet tiles, the drawn tapes are annealed to render the same resistant to shrinkage. Annealing is carried out by heating the tapes to above glass transition temperature of the poly(ethylene terephthalate) component in a relaxed state. Conveniently, the drawn tapes are passed around two or more rolls heated to above glass transition temperature of the poly(ethylene terephthalate) component but below about 165° C, to avoid excessive softening of the propylene polymer component and loss of yarn properties, with reduction in roll speed so that the softened yarn can shrink. Before annealing, shrinkages of up to 20% are typical of the drawn tapes; reductions to about 1-4% can be achieved by annealing at about 138 to about 165° C with speed reduction of at least about 10% over a series of rolls.

The drawn or drawn and annealed tapes subsequently can be taken up by conventional means. Alternatively, the yarns can be fed to a loom for weaving into woven carpet backing fabrics or other fabrics. Weaving of the yarns is conducted by conventional techniques. Application of antistatic agents and lubricants of the type commonly employed with polyester yarns facilitates weaving.

Carpet backing fabrics and other fabrics woven from the invented yarns comprise woven warp and fill yarns, at least one of which comprise the invented yarns. The invented yarns can constitute both warp and fill yarns of the fabric, as in a primary carpet backing fabric. Alternatively, warps of the invented yarns, alone or in combination with other yarns, can be woven with other fill yarns or vice versa to provide other desired fabric structures. Generally, when the invented yarns are used as warp yarns in weaving of carpet backing fabrics, yarns about 30 to about 300 mils wide and about 1.5 to about 3.5 mils thick are used. When used as fill yarns, widths generally range from about 75 to about 500 mils and thicknesses range from about 1.5 to about 3.5 mils. Fabric constructions having about 5 to about 30 warp yarns per inch and about 5 to about 20 fill yarns per inch are suitably employed as backings, precise construction varying somewhat depending on backing style. Tufted carpets comprising such woven backings can be prepared by conventional tufting and finishing procedures.

For use in weaving primary carpet backing fabrics for tufted carpets for carpet tiles, preferred yarns according to the invention have tenacities of about 3.2 to about 4.5 grams per denier, elongation of about 20 to about 30% and dry shrinkages of about 1.5% or less. Warp yarns about 40 to about 60 mils wide by about 1.5 to about 2.8 mils thick and fill yarns about 75 to about 125 mils wide by about 1.5 to about 2.8 mils thick are most preferably employed. A preferred fabric construction for such backings is about 12 to about 30 warps per inch by about 10 to about 18 fills per inch. The tufted backings typically are backed with foam, such as polyurethane or vinyl, in the final carpet tile assembly.

For use in weaving primary carpet backings for tufted carpets for automotive applications preferred yarns according to the invention have tenacities and dimensions as described above, elongations of about 30 to about 45% and dry shrinkages of about 1% or less. Backing fabric construction preferably is about 18 to about 30 warps per inch by about 8 to about 16 fill yarns per inch. In the automotive carpet, the tufted backing is coated with a latex or hot melt adhesive backcoat.

The present invention is illustrated by the following examples, it being understood that the same are not intended as limiting the scope thereof.

EXAMPLE 1

To a V-cone rotating blender were added 279.3 pounds of homopolymer poly(ethylene terephthalate) pellets, identified as Cleartuf 8007C from Goodyear, having an intrinsic viscosity of 0.8 dl/g in o-chlorophenol, determined according to ASTM D-2857 and 39.2 pounds of crystalline polypropylene pellets having melt flow rate of 3.5 g/10 minutes according to ASTM D-1238, Condition L, and 31.5 pounds of pellets of a polypropylene-based concentrate containing minor amounts (less than 0.5 percent by weight of the total blend) of titanium dioxide and carbon black for color, opacity and delustering. The blend contained 25 percent polypropylene by weight of the poly(ethylene terephthalate). The blend then was tumble-mixed for 1-2 hours, loaded into a desiccant bed-hot air recirculating dryer and dried for about ten hours at an air temperature of 135 ° C. Estimated water content after drying was about 50 ppm.

The dried blend was subsequently loaded into the hopper of a 2.5 inch Black Clawson extruder equipped with a barrier-flight polyester screw. The extruder barrel temperatures were set at a flat 291 ° C profile, with the exception of the first zone, which was set at 274 ° C. The blend was extruded through a 6-layer screen mesh and into a coat-hanger film die, with its gap set at 0.010 inch. Extrusion rate was controlled to yield a film with an unoriented thickness of approximately 0.005 inch.

The film was cast onto a 24-inch diameter chill roll rotating so as to provide a linear speed of about 58 ft/minute with its temperature controlled at about 66 ° C with recirculating water, the chill roll being located less than one-half inch from the die outlet.

The film was conveyed from the chill roll over conveying rolls and passed over a bar equipped with a series of tungsten carbide razor blades at about 60 ft/minute. The blades slit the moving film into tapes. Tapes designated A were slit into widths of about 91 mils from the film. A second film prepared in like manner was slit into tapes, designated B, about 200 mils wide. The tapes were conveyed via rotating rolls onto a hot plate surface for drawing. The plate temperature was set at about 91-96 ° C. Drawing was carried out at a draw ratio of about 4.5:1 to 4.75:1, with a final tape draw speed of about 270 feet per minute.

The drawn tapes were conveyed over additional rolls to a series of seven rolls for annealing. Roll surface temperatures were set at about 154 ° C, and speed was reduced linearly from 270 feet per minute to approximately 245 feet per minute from the first to the last rolls. The last roll was chilled to 16 ° C with cold water recirculation. The finished tapes were wound onto bobbins.

The tapes were found to have the following physical properties:

	TAPE A	TAPE B
Dimensions (mils)	48x2	95x1.9
Denier	680	1250
Tenacity (g/denier)	3.5	3.3
Elongation (%)	30.0	25.5
Dry Shrinkage (%@ 270 ° F)	2.3	2.1

A lubricating finish was applied to the tapes and the same were woven into a plain weave fabric using TAPE A as warp yarns and TAPE B as fill yarns. Fabric construction was 24 warp yarns per inch by 13 fill yarns per inch. The backing was tufted with bulked continuous filament nylon yarns (1/8 guage x 6-8 stitch) by needling. Visual inspection during and after needling showed substantially uniform rows of tufts in both the warp and fill directions without significant yarn or needle breakage.

COMPARATIVE EXAMPLE 1

This example illustrates production of yarns from poly(ethylene terephthalate) without use of a propylene polymer component and their performance as a woven primary carpet backing.

Poly(ethylene terephthalate) pellets (Goodyear Cleartuf 9506B) having intrinsic viscosity of 0.95 dl/g in

o-chlorophenol according to ASTM D-2857, were dried in the dryer used in Example 1 for 4 hours at about 149° C to an estimated water content of about 50 ppm. The dried pellets then were fed to the extruder used in Example 1 and film was formed essentially as described in that example. After slitting into tapes (100 mils x 2 mils) the tapes were drawn on the hot plate, essentially as in Example 1, at a ratio of 5:1. No annealing was performed. The product yarns had the following properties:

Denier	700
Tenacity (g/den)	4.4
Elongation (%)	13.8

Due to static generation, weaving of these tapes was difficult until a lubricant/finish was added. When the tapes were woven into a plain weave fabric having about 20 warps per inch and about 12 fill yarns per inch, and needled with face yarn essentially as in Example 1, tufting performance was unacceptable. The tufting needle could not directly penetrate the polyester yarns. Yarns broke and the needle deflected to one side of the yarns, yielding a distorted and damaged tufted backing.

EXAMPLE 2

Raw materials, blended in a batchwise fashion as described in Example 1, were dried and extruded into film following essentially of procedure of Example 1. Tapes were drawn at a ratio of 4.5:1 on the hot plate. The drawn tapes then were carried over a series of seven rolls for annealing with speed reduction as in Example 1. Initially, tape was collected which bypassed the seven-roll annealing equipment. Then, with tape brought through the roll system, roll temperatures and relax rates (% reduction in speed between the first and seventh rolls) were increased in steps. In all cases, only the first six rolls were heated at temperatures as shown below. The seventh roll was chilled to about 16° C. The following shrinkage results, determined by ASTM D-3334.11, were obtained.

% Relax	Roll Temperatures (° F)	Dry Shrinkage(% @ 270° F)
0.1	Bypassed	17.9
5.6	250	10.7
5.6	275	9.1
11.1	275	5.8
9.6	300	2.0

Dry shrinkage values of 2% and less are considered to be in the practical range of acceptable carpet backing performance. As can be seen from the results of this example the combination of about 10% relax and 300° F roll temperature gave acceptable shrinkage, whereas lower relax and temperatures gave higher shrinkages.

COMPARATIVE EXAMPLE 2

Nine parts by weight of the poly(ethylene terephthalate) used in Comparative Example 2 and one part by weight (11.1% by weight of poly(ethylene terephthalate)) of polypropylene of the type used in Example 1 were mixed and dried in the dessicant-drying unit used in Example 1 for about 8 hours at about 121° C. The dried mixture was fed to the extruder and formed into film and slit into tape essentially as described in Example 1 without difficulty. Tapes were drawn at ratios of 4.1:1 and 5.0:1, but were not annealed.

Fabric woven from the tapes essentially as in Example 1 behaved in a manner similar to the fabric

prepared in Comparative Example 1. The tapes would not allow a tufting needle to penetrate without producing unacceptable distortion.

EXAMPLE 3 AND COMPARATIVE EXAMPLE 3

Two raw material batches were prepared by mixing pellets of the poly(ethylene terephthalate) and polypropylene components used in Example 1. The first, designated EXAM PLE 3 contained 33% polypropylene by weight of the poly(ethylene terephthalate). The second, Comparative Example 3, contained about 54% polypropylene by weight of poly(ethylene terephthalate). These mixes were dried at about 121 °C overnight and extruded into film following essentially the procedure of Example 1. The extruder profile began at about 279 °C in the feed zone and increased linearly to about 291 °C at the die. Tapes were drawn at 4.5:1 at a hot plate temperature of about 94 °C. No annealing was performed. Qualitatively, slitting and drawing of the Example 3 blend was comparable to that of the material of Example 1. Comparative Example 3 deposited a significant amount of dust on the cutting and drawing equipment.

Properties of the resultant yarns were as follows:

	Example 3	Comparative Example 3
Denier	660	653
Tenacity (g/den)	3.75	3.40
Elongation (%)	25.4	21.1

As can be seen, the comparative yarns were only slightly weaker than the Example 3 yarns. However, in addition to the former's increased dusting potential, the yarns split so easily by hand that they were determined to be unsuitable for weaving and tufting. The Example 3 yarns did not split excessively and were deemed suitable for weaving and tufting.

EXAMPLE 4

Poly(ethylene terephthalate) having intrinsic viscosity of 0.8 dl/g in o-chlorophenol according to ASTM D-2857 (Goodyear Cleartuf 8007C) was fed through a continuous hot-air desiccant-bed dryer, where it had a residence time of at least 4 hours at about 149 °C. It then was introduced into a closed volumetric auger-feed system, where it was blended with the polypropylene and a pigmented polypropylene-based concentrate similar to that used in Example 1 in the proportions used in that example. The mixture then entered a 4.5 inch Davis-Standard extruder and was extruded through a 54 inch coat-hanger die onto a chill roll. The chill roll and an air knife were located immediately next to the outlet of the die. As in Example 1, the film was conveyed to the slitting area, cut into tapes and drawn on a hot plate. Drawing and annealing were done under the same conditions as in Example 1 after which the yarns were wound onto bobbins. The yarns had the following properties:

	TAPE A	TAPE B
Dimensions (mils)	49x2	92x1.9
Denier	730	1308
Tenacity (g/den)	3.3	3.6
Elongation (%)	34.2	33.3
Dry Shrinkage (% @ 270 °F)	1.6	1.9

After application of lubricant, the yarns were successfully woven into fabric (24 warps per inch of TAPE A yarns by 13 fills per inch of TAPE B yarns) on a 154 inch loom, which performed well in tufting as a

primary carpet backing.

Claims

1. Yarn of substantially flat cross-section comprising a poly(ethylene terephthalate) component having dispersed therein about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component.

2. Yarn according to Claim 1 comprising about 20 to about 35 percent propylene polymer component by weight of the poly(ethylene terephthalate) component.

3. Yarn according to Claim 1 or Claims 2 wherein the propylene polymer component consists of polypropylene homopolymer.

4. Yarn according to any preceding claim wherein the poly(ethylene terephthalate) component consists of homopolymer poly(ethylene terephthalate).

5. Yarn according to Claim 1 comprising a poly(ethylene terephthalate) component having dispersed therein about 25 to about 33 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline polypropylene homopolymer component and prepared from a blend of a poly-(ethylene terephthalate) component having intrinsic viscosity of about 0.75 to about 0.85 dl/g in o-chlorophenol according to ASTM D-2857 and a substantially crystalline polypropylene homopolymer component having melt flow rate of about 3 to about 14 g/10 minutes according to ASTM D-1238, Condition L.

6. Yarn according to any preceding claim of substantially flat, rectangular cross-section.

7. Carpet backing fabric comprising woven warp and fill yarns, at least one of which comprise yarn according to any of Claims 1-6.

8. Tufted carpet comprising a primary carpet backing having a plurality of tufts projecting outwardly from one surface thereof and a plurality of tuft stitches on a second surface thereof, wherein the primary carpet backing comprises the carpet backing fabric according to Claim 7.

9. Carpet tile or automotive carpet comprising the tufted carpet according to Claim 8.

10. A resinous blend comprising a poly(ethylene terephthalate) component having intrinsic viscosity of about 0.7 to about 1.0 dl/g in o-chlorophenol according to ASTM D-2857 and about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component having a melt flow rate of about 3.5 to about 5 g/10 minutes according to ASTM D-1238 Condition L.

11. A process for producing tape yarns suitable for weaving comprising (a) forming a molten, intimate mixture from components comprising a poly(ethylene terephthalate) component having intrinsic viscosity of about 0.7 to about 1.0 dl/g in o-chlorophenol according to ASTM D-2857 and about 17 to about 43 percent, by weight of the poly(ethylene terephthalate) component, of a substantially crystalline propylene polymer component having a melt flow rate of about 2 to about 18 g/10 minutes according to ASTM D-1238, Condition L, said mixture being substantially free of water; (b) extruding the molten mixture through a film die onto a chill roll to obtain a quenched film of substantially uniform thickness; (c) slitting the quenched film along its length into a plurality of tapes; and (d) drawing the tapes at a draw ratio of about 4:1 to about 5.5:1.