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(54) HYBRID YARNS WHICH INCLUDE OIL SEED FLAX PLANT BAST FIBER AND OTHER FIBERS AND FABRICS MADE WITH SUCH YARNS

(76) Inventors: **Mikhail Khavkine**, Winnipeg (CA); **Barbara Isman**, Winnipeg (CA)

Correspondence Address:
FITCH EVEN TABIN AND FLANNERY
120 SOUTH LA SALLE STREET
SUITE 1600
CHICAGO, IL 60603-3406 (US)

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(57) **ABSTRACT**

The invention is directed to (1) hybrid yarns which include oilseed flax straw plant bast fibers and a second group of fibers which may be synthetic and/or natural plant fibers, and (2) fabrics made from such yarns.

HYBRID YARNS WHICH INCLUDE OIL SEED FLAX PLANT BAST FIBER AND OTHER FIBERS AND FABRICS MADE WITH SUCH YARNS

[0001] The present application is a non-provisional application claiming priority under 35 USC 119(e) to U.S. Provisional Application No. 60,290,856, of Khavkine et al., entitled HYBRID YARNS WHICH INCLUDE OIL SEED FLAX PLANT BAST FIBER AND OTHER FIBERS AND FABRICS MADE WITH SUCH YARNS, filed May 14, 2001.

[0002] The invention is directed to (1) hybrid yarns which include natural oilseed flax plant bast fibers and other natural and/or synthetic fibers, (2) fabrics made from such hybrid yarns, (3) composite reinforcements which include the fabrics and yarns of the invention, and a method of making such hybrid yarn. The yarns and reinforcing fabrics of the invention are low cost, light weight and environmentally-friendly. The yarns and fabrics are particularly useful for low to medium strength applications such as composite reinforcements and as garment fabrics. The significant advantages of the invention include the use of natural flax plant bast fibers in combination with other natural and/or synthetic fibers which provide desired mechanical properties for the hybrid yarn and fabrics of the invention.

BACKGROUND OF THE INVENTION

[0003] A number of different materials, such as organic and inorganic fibers, have been used to make composite reinforcements, particularly reinforcements for low and medium strength applications. Inorganic fibers include glass and carbon filaments, filaments of metals or metal alloys such as steel, aluminum or tungsten; non metals such as boron; or metal or nonmetal oxides, carbides or nitrides such as aluminum oxide, zirconium oxide, boron nitride, boron carbide or silicon carbide, ceramic filaments, filaments of slag, stone or quartz. Organic fibers include aramid, nylon, polypropylene, polyethylene, polyester and natural fibers, such as cotton and wood.

[0004] Traditionally, fiberglass has been the most popular material for almost any composite reinforcement application. Fiberglass has unique combination of versatility and strength that made this reinforcement a material of choice for more than 50% of all composite articles manufactured in the year 2000. Nylon, polyester, and polypropylene fibers are another composite reinforcement alternative. They have been used extensively for low and medium strength composite reinforcement applications. Despite their good availability, fiberglass, nylon, polyester, and polypropylene fibers have significant disadvantages, including high prices tied to crude oil prices. All of these materials pressure the environment because they are not necessarily renewable, do not biodegrade and generate significant Green House Gases emission upon manufacture and/or destruction. Key disadvantages of fiberglass also include the worker unfriendly nature of the material (fiberglass is an irritant), its fragility which makes it difficult to process; and finally, its density (natural fibers have specific density that is 40% less than density of fiberglass).

[0005] With respect to yarns and fabrics for garments, natural fibers, particularly, oilseed flax straw fibers, unfortunately are limited in length, resilience or crush resistance properties. In many garment or technical applications, better toughness, strength, recovery properties and degree of liveliness heretofore not attained are very desirable. It is very common in the textile industry when yarn made up of different fibers, either natural or synthetic, or the yarns may be made up of the same type fiber but have slightly different qualities, even when unintended. The different fibers often have varying dye characteristics, and if package dyeing of the hybrid yarn or piece dyeing is later employed, the fibers may attain visibly different color shades, giving the resulting product a variegated appearance. A variegated appearance may also arise from the differing texture or other properties of the individual fibers. While a variegated appearance may be desirable in itself, yarn patterning tends to produce micro-streaks or other patterns which repeat throughout the textile product in which the hybrid yarn is used.

[0006] Hybrid yarns from non-thermoplastic reinforcement filaments (e.g. aramid, glass or carbon fiber) and thermoplastic filaments (e.g. polyester fiber) are well known. For instance, the patent applications EP-A-0,156,599; EP-A-0,156,600; EP-A-0,351,201 and EP-A-0,378,381 as well as Japanese Publication JP-A-04/353,525 and U.S. Pat. No. 5,792,555 consider hybrid yarns made of non-thermoplastic fibers (e.g. glass or aramid filaments or rovings) and thermoplastic fibers (e.g. polyester or PET filaments or rovings). Thermoformable textile materials (e.g. plain weave fabrics) are made from thermoformable hybrid yarns having high melting point and non-melting filament or fibers. These textile materials can be converted into fiber reinforced, stiff thermoplastic sheets that may be used for different structural applications.

[0007] Various methods of producing fiber reinforced thermoplastic sheets are described in Chemiefasern/Textiltechnik, volume 39/91 (1989) pages T185 to T187, T224 to T228 and T236 to T240. Processes are described which start with a woven mat composed of hybrid yarns. The advantage of these techniques are a mixing ratio of reinforcing and matrix fibers that can be very precisely controlled, as well as the drapability of the textile materials which makes it easy to process the material by compression moulding (Chemiefasern/Textiltechnik, volume 39/91 (1989), page T186).

[0008] EP-A-0,268,838 describes reinforcing textile material a layer of longitudinal threads and a layer of transverse threads, which are not interwoven. One of the plies of threads has a significantly higher heat shrinkage capacity than the other. Auxiliary threads provide cohesion. These auxiliary threads do not tightly bind the layers of the reinforcing threads together, but rather loosely fix them to one another so that they can move relative to one another.

[0009] DE-A-4,042,063 describes making easily deformed reinforcing layers. Longitudinal heat-shrinking and auxiliary threads are incorporated into a sheet material intended for use as textile reinforcement. Heating causes the textile material to contract as some extent, so that the reinforcing threads are held in a wavy state or in a loose looping.

[0010] U.S.Pat. No. -6,51,313 describes yarn that is formed from non-twisted discontinuous parallel fibers held together by a covering yarn of sacrificial material wound around the fibers. The fibers comprise an intimate mixture of fibers of at least two different types: 1) carbon fibers or pre-oxidized polyacrylonitrile based carbon precursor fibers, 2) anisotropic or isotropic pitch based carbon precursor fibers, 3) phenolic or cellulosic based carbon precursor fibers, and 4) ceramic fibers or ceramic precursor fibers. In a carbon state, the mixture of fibers comprises at least 15% by weight of high strength fibers having a tensile strength of at least 1500 Mpa and a modulus of at least 150 Mpa, and at least 15% by weight of fibers with a low Young's modulus of at most 100 GPa.

[0011] DE-A-3,408,769 discloses a process for producing shaped fiber reinforced articles from thermoplastic material by using flexible textile structures consisting of substantially unidirectional aligned reinforcing fibers and a matrix constructed from thermoplastic yarns or fibers. Final shaping of a composite takes place after passing heated dies where virtually all of the thermoplastic fibers melt and bind the reinforcement.

[0012] It has been found that yarns in the prior art have significant disadvantage for low to medium strength composite reinforcement applications. Known reinforcements are designed for high performance applications and they are too expensive for broad use in cost sensitive applications like construction materials and interior trim automotive parts. Another disadvantage of reinforcing materials described in the previous art is difficulty in handling of these materials due to their irritant nature (e.g. fiberglass and carbon fibers).

SUMMARY OF THE INVENTION

[0013] This invention relates to natural fiber based hybrid yarns, fabrics made from such yarns and composite reinforcements which include the yarns and/or fabrics made from such yarns and a method for making such yarns. The yarns, fabrics and reinforcements of the invention advantageously include oilseed flax straw plant fibers bast which agri-by-products, straw that otherwise would be burned on the field and contribute to the Green House Gases emission. Indeed, each year about 1,000,000 tons of oil-seed flax straw is burnt in North America only.

[0014] The hybrid yarns of the invention comprise flax bast fibers and a second filament group which is selected from the group consisting of synthetic fibers, natural plant fibers, other than oil seed flax bast fibers, and mixtures thereof. In an important aspect, the second filament group includes cellulose or modified cellulosic fibers, acrylic fibers, polyester fibers, polyamide fibers, olefin fibers, thermoplastic fibers and mixtures thereof. The first and second filaments are in the hybrid yarn in an amount and twisted in an amount which is effective for making the yarns having a tenacity of at least about 0.8 grams/Denier and a Young's tensile modulus of at least about 6 g/Denier. The present invention is particularly advantageous because it can utilize North American oil seed flax varieties including CDC Normandy, AC Watson, Somme, and Bethune. As used herein, "bast fibers" are those fibers from the phloem region of the flax plant and are not "shives" which form a part of the core tissue of the plant stock.

[0015] The hybrid yarns of the invention include at least the two aforedescribed groups which are twisted together to form the yarn. The first group includes oilseed flax plant bast fibers having a tensile strength of at least about 1 GPa, a tenacity of at least about 1.5 grams/Denier, a breaking elongation of from about 1 to about 20% and a crimp of from about 5 to about 80%. The oilseed flax plant bast fibers have an average fiber length of from about 15 mm to about 75 mm and a Young's tensional modulus of at least about 87 Gpa.

[0016] The second group comprises a second filament group, which is selected from the group described above, has a fiber tenacity of above about 1.5 gram/Denier and a breaking elongation of from about 5 to about 75%.

[0017] The oilseed flax plant bast fibers of the present invention are blended with a hydrophobic lubricant and antistat. Preferably, this blending is during the blending of the flax plant bast fibers with the second filament group and prior carding of the blended fibers. Flax plant bast fibers are treated with an amount of hydrophobic lubricant and antistat that is effective for increasing the affinity of the bast fibers to the surface of the second filament group and permit the ring or open spinning thereof. The hybrid yarn will include about 0.1% to about 0.5% of hydrophobic lubricant, based on the dry weight of the fibers, and from about 0.1% to about 1% of antistat, based on the dry weight of the fibers. Preferably, the hybrid yarn will include about 0.2% to about 0.3% hydrophobic lubricant, based on the dry weight of the fibers, and a weight ratio of hydrophobic lubricant to antistat of about 80 to 20. A hybrid yarn of the invention having a moisture content of about 12% will have at least about 0.3% by weight hydrophobic lubricant and at least about 0.2% by weight antistat.

[0018] The hydrophobic lubricant of the invention includes compositions that contain nonionic hydrocarbon surfactants and lubricant bases that include alkyl phosphate esters, alkyl esters of fatty acids, polyoxyethylene lauryl ether and polyoxyethylene tridecyl ether blended in an inert carrier. Antistats of the present invention include antistat compositions having at least one neutralized C_3-C_{12} alkyl or alkenyl phosphate alkali metal or alkali earth metal and a solubilizer.

[0019] The surface characteristics of the oilseed flax bast fibers are enhanced such that they are effective for spinning when treated as described above with hydrophobic lubricant and antistat.

[0020] The yarn is processed by short staple ring or open spinning the flax bast fibers and the and the second filament group. The hybrid yarn is a mixture of at least about 30% by weight of natural oil seed flax bast fibers and not more than about 70% by weight of synthetic and/or natural fibers other than the oil seed flax bast fibers. In an important aspect, the hybrid yarn of the invention is produced by ring spinning which provides a high degree of twisting. As a part of the spun yarn, the first fiber group can include an additional bast fibers which comes from a plant other than an oilseed flax plant.

[0021] The yarn can be woven into a large variety of textile products, including into open mat type products, and particularly into open mat products with openings that have an area in a range of about 0.2 to about 100 mm^2. The significant advantage of the oilseed flax bast fiber based yarns over fiberglass, carbon and other stiff high performance fibers is the ease of processing natural fiber based yarns into a variety of textile products cost effectively on a very large scale.

[0022] In a reinforcement aspect of the invention, the fabric of the invention is an open thermoformable mat that is capable of being used for manufacturing reinforced composite articles which are produced by deforming the thermoformable textile sheet-like mats of the invention.

[0023] The open thermoformable woven mat can be uni- or multidirectionally placed to provide an article having an adjustable high strength in two or more directions. The reinforced composites of the invention include either the yarns or the woven open mats of the invention.

[0024] In yet another reinforcement aspect of the invention, the yarn is a thermoformable hybrid yarn which has at least two groups which are twisted together to form the yarn. The first fiber group which comprises oilseed flax plant bast fibers having have a length of from about 15 mm to about 75 mm, a tenacity of at least about 1.5 grams/Denier, a breaking elongation of from about 1 to about 20% and a crimp of from about 5 to about 80%, the oilseed flax plant bast fibers. The second filament group comprises at least one thermoplastic filament having a melting point of at least about 10° C. and below the thermal decomposition point of the oilseed flax plant bast fibers, wherein the first and second group are ring spun to a yarn.

DETAILED DESCRIPTION OF THE INVENTION

[0025] The hybrid yarns of the invention consists of two groups of fibers or filaments. One group is oilseed flax plant bast fibers having a tensile strength of at least bout 1 GPa, a tenacity of at least about 1.5 grams/Denier, preferably from about 2 to about 8 grams/Denier, and most preferably from about 2.5 to about 7 grams/Denier, a breaking elongation of from about 1 to about 20%, preferably from about 2 to about 10% and most preferably about 2.5 to about 6%. These flax bast fibers have an average fiber length of from about 15 mm to about 75 mm.

[0026] The second filament group is selected from the group consisting of synthetic fibers, natural plant fibers, other than oil seed flax bast fibers, and mixtures thereof. The second filament group has a fiber tenacity of above about 1.5 gram/Denier, preferably from about 2 to about 20 grams/Denier, most preferably from about 5 to about 10 grams/Denier, and a breaking elongation of from about 5 to about 75%, preferably from about 9 to about 70% and most preferably from about 9.5 to about 70%. The second filament group can include cellulose or modified cellulosic fibers, acrylic fibers, polyester fibers, polyamide fibers, olefin fibers, thermoplastic fibers and mixtures thereof. As used herein, the term thermoplastic fibers refers to fibers comprising resins including polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), styrene resins, acrylonitrile resins, acrylonitrile-styrene resin (ABS) and the like, their compounded mixtures, their copolymers, their reactive modified resins and the like.

[0027] It is important that the bast fibers used in the invention are not weakened by virtue of their separation from the plant and woody portions of the plant. Many processes for isolating bast fibers from the plant include chemical treatment and machines which use a scutching, beating or failing action as a primary separation mechanism. Many of these processes weaken the bast fibers. This weakening ultimately causes breakage and shortening of the fibers. This is especially a concern for flax straw grown in North America which tends to have shorter bast fibers than for example European flax straw. In view of this circumstance, flax bast fibers may be recovered and separated from other plant materials such as shives in the plant stock by the processes and equipment described in U.S. Pat. No. 5,720,083; 5,906,030; and 6,079,647 are ideal for recovering bast fibers which may be used in the invention. North American oil seed flax varieties that can be utilized in the present invention include CDC Normandy, AC Watson, Somme, and Bethune.

[0028] In addition to having strong oilseed bast fibers having an average length of from about 15 mm to about 75 mm, the surface characteristics of the oilseed flax bast fibers after blending with hydrophobic lubricant and antistat as described herein are enhanced such that the fibers are effective for use in open end and ring spinning.

[0029] During blending of the bast fibers with the second filament group and prior to carding, the bast fibers are blended with a lubricant and antistat to provide a hybrid yarn having at least about 0.1% to about 0.5% of hydrophobic lubricant, based on the dry weight of the fibers, and from about 0.1% to about 1% of antistat, based on the dry weight of the fibers. Preferably, the hybrid yarn will include about 0.2% to about 0.3% hydrophobic lubricant, based on the dry weight of the fibers, and a weight ratio of hydrophobic lubricant to antistat of about 80 to 20.

[0030] Lubricants that may be blended with the bast fibers include lubricants containing nonionic hydrocarbon surfactants such as polyoxyethylene, polyethylene glycol 400 distearate, polyethylene glycol 300 distearate, polyethylene glycol 200 distearate, polyethylene 600 distearamide, and glycerol monosterate. Other suitable lubricants include self-emulsifiable, textile-fiber, lubricant bases and lubricant compositions. Effective lubricant bases include from about 2% to about 20% sodium or potassium alkyl phosphate ester, from about 15% to about 50% alkyl ester of a fatty acid, from about 25% to about 45% polyoxyethylene lauryl ether, and from about 5% to about 25% polyoxyethylene tridecyl ether. The lubricant bases are mixed with inert carrier liquids such as mineral oil or aqueous solutions and then applied to the bast fibers. The amount of lubricant blended with the bast fibers is effective for providing a coefficient of friction of less than about 0.35.

[0031] Antistatic compositions that can be used in the present invention includes antistats that include at least one neutralized C_3-C_{12} alkenyl phosphate alkali metal or alkali earth metal salt and a solubilizer. Solubilizers include glycols, polyglycols, diethylene glycol, polyethylene glycol, and potassium or sodium oleyl (ethylene oxide) phosphate having an ethylene content range of from about 2 to about 9 moles. The amount of antistat blended with the bast fibers is effective for limiting electrostatic charge to less than about 4000 volts during processing, and in a preferred aspect, to less than about 500 volts during processing.

[0032] Hydrophobic lubricant and antistat may be applied during a fiber blending stage, for example, in a low speed blender, and before carding. In this aspect of the invention, hydrophobic emulsions of lubricant and antistat may be simultaneously sprayed with jet sprayers onto the fibers.

[0033] An advantage of the reinforcing hybrid yarn of the invention is that the yarn may be produced by ring spinning which provides a high degree of twisting. The twisted yarns have a significant advantage in terms of tensile properties over non-spun filament bundles or other types of spinning that does not put a strong twist on the yarn. Ring spinning enables relatively weak fibers to form strong yarns. At the same time, any spun yarns have significant advantage over yarns made from non-spun filaments (e.g. fiberglass yarns), due to bundle coherency. The hybrid yarn is easier to process into sheet materials on conventional machines, for example weaving or knitting machines. This is very important for a thermoformable composition where intimate mixing of the reinforcing and matrix fibers results in very short flow paths for the molten matrix material. This property provides superior and complete embedding of the reinforcing fibers in the thermoplastic matrix; e.g., when a sheet moulding material is shaped into fiber reinforced thermoplastic composite article.

[0034] Hybrid yarn that is a combination of oilseed flax bast fibers and polypropylene filaments which may be ring spun at a ratio of 75 flax to 25 polypropylene to have about 15.3 twist per inch. Hybrid yarn having at ratio of 50 flax to 50 polypropylene may be ring spun to have about 21.4 twist per inch. Hybrid yarn having at ratio of 60 flax to 40 polypropylene and open end spun had about 16.97 twists per inch.

[0035] In the aspect of the invention which includes thermoplastic filaments for a reinforcing agent, the thermoplastic filaments have a melting point which is at least 10° C., preferably 20° to 225° C., below the thermal decomposition point of the oilseed flax bast fibers. These thermoplastic filaments have a crimp of 5% to 80%, preferably of 12 to 50%, in particular of 18 to 40%. In this aspect, the hybrid yarn is easier to process into sheet materials on conventional machines, for example weaving or knitting machines. This is very important for a thermoformable composition where intimate mixing of the reinforcing and matrix fibers results in very short flow paths for the molten matrix material. This property provides superior and complete embedding of the reinforcing fibers in the thermoplastic matrix; e.g., when a sheet moulding material is shaped into fiber reinforced thermoplastic composite article. In this aspect, the present invention is effective for providing permanently deformed composite material that includes a hybrid yarn that is a combination of themoplastic filaments and oilseed flax bast fibers. "Permanent deformation" or "permanently deformed" refers to a property of the composite material where a composite material that is formed under heat and pressure retains its shape indefinitely or until the article is destroyed.

EXAMPLES

Raw Materials

[0036] 1. 200 pounds of flax fibers having 2-inch staple length for processing into yarn in blend with polyester fibers.

[0037] 2. Polyester fibers with a 2-inch width and 3 denier.

[0038] At the blending stage, fibers are treated with:

[0039] 1) Anionic antistatic agent Lurol PP-920 (Goulston Technologies) is applied at the fiber blending stage as a 10% water solution to achieve a 0.2% concentration of active ingredients on a dry fiber weight basis.

Chemical and Physical Properties:	
Classification:	Anionic
Appearance:	Amber Liquid
Viscosity (cSt @ 25° C.):	Approximately 12.0
Activity	50%

[0040] Dilution Procedure:

[0041] Stable emulsions of Lurol pp-920 are prepared by adding Lurol PP-920 to room temperature water slowly while mixing.

[0042] Finish Level Measurements:

[0043] The amount of Lurol pp-920 on fiber is measured by conventional extraction methods using iso-propanol, methanol, or any polar based solvent.

[0044] 2) Lurol PP-6845 (Goulston Technologies, Inc.) hydrophobic lubricant is applied at the fiber blending stage as a 5% water emulsion to achieve a 0.3% concentration of the active ingredient on a dry fiber weight basis.

Chemical and Physical Properties:	
Appearance:	milky emulsion
Viscosity (5° C.):	7 cPs
Activity	40%
pH	6
Particle size	0.9 μ
Surface tension, 20%	55 dyne/cm^3

[0045] Application:

[0046] Lurol PP-6845 is used in conjunction with a suitable antistatic agent. Lurol PP-6845 is applied at the fiber blending stage. Lurol PP-6845 may be diluted to the desired concentration by stirring into demineralized water at 22-30° C. The emulsion is stable for 48 hours with agitation.

[0047] Finish level measurement:

[0048] The finish on yarn is measured by supercritical fluid extraction or by solvent extraction using iso-propanol as solvent.

[0049] The following processes maybe used to convert the flax fibers as supplied into yarn:

[0050] 1. Cleaning and opening,

[0051] 2. Carding,

[0052] 3. Drawing single pass, and

[0053] 4. Ring spinning.

Opening and Cleaning

[0054] The fibers are hand fed into a WRZ pre-cleaner (similar to an axi-flow cleaner) having two rows in line with porcupine beaters and then pneumatically transferred into a lint cleaner, which is similar to a Saco-Lowell card. The lint cleaner's cylinder rpm is 500 and 222 pts./inch^2, and the licker-in rpm is 1,100 having 96-100th/inch^2. About 30% waste is generated.

[0055] Carding, is carried out with Marzoli C300 card for both 75/25 and 50/50 flax/polypropylene blends.

Blending and Carding

[0056] Both the flax and polypropylene are hand blended after weighing them into the right proportions. Small tufts of the blended fibers are fed into Fiber Control's opening and blending line. A 310 vertical fine opener further opens and blends the tufts. The blend material is fed through the chute to the card. At blending, TS-1 oil and water are sprayed with a Gintex mister. The following machine settings are used.

Chute Front =	½ closed
Beater Setting =	5.0
Fan Setting =	5.0
Licker-in, rpm =	512
Cylinder, rpm =	301
Doffer, rpm =	40
Flat Speed =	6 inches min^{-1}
Licker-in Wire Density =	24 pts. inch^{-2}
Cylinder Wire Density =	850 pts. inch^{-2}
Doffer Wire Density =	350 pts. inch^{-2}
Flat Wire Density =	280 pts. inch^{-2}
Rear Fixed Flat Setting =	0.29 inch
Moving Flat Setting =	0.29 inch
Front Fixed Flat =	0.20 inch
Setting Silver Wt. gram =	72.5

Drawing

[0057] Card sliver is drawn single pass on a Rieter 851 draw frame using the following specifications:

Total Draft =	5.05
Break Draft =	1.87
Front Zone Setting =	50 mm
Back Zone Setting =	53 mm
Number of Ends Up =	4
Delivery Tension to Coiler =	0.99
Speed, m/m =	400
Draw Sliver Size, gram/yard =	58.6

Ring Spinning

[0058] Blended draw sliver are spun on a Marzoli NSF2 ring frame. The following spinning parameters are used.

	75/25 Flax/PP	50/50 Flax PP
Twist, inch^{-1}	15.3	21.4
Builder	12.0	6
Ring Diameter, mm	48	48
Middle Roll	No Clips	No Clips
Pressure		
Back Roll Pressure	Black	Black
Rear Condenser	8 mm	8 mm
Front Condenser	6 mm	6 mm
Yarn Count	7/1	12/1

B. Open-end Spinning

[0059] The open-end yarn is spun from 60/40 flax/polyester single-pass draw sliver (53 grain/yard). The blended sliver is spun on a Rieter R-20 rotor open-end spinning frame. An 8/1 single yarn is produced using the following set up:

Feed, m/min	1.83
Draft	41
Comber roll type	X 6014D
Face plate	D40
Navel	KS
Doffing tube	Soft twist
Twist multiplier	6
Turns per inch	16.97
Delivery roll speed, m/min	75.1
Winding angle, deg.	33.6
Room condition	58% RH and 83°/F.

Fabric

[0060] The 8/2 flax/PET yarn is warped on a sample warper and then woven without sizing on a rapier loom. The fabric construction is 13 ends/inch and 13 picks/inch in a plain weave design. No difficulties in warping and weaving should be found. The 8/1 yarns are plied to produce 2/8 (4^5) as required by the fabric specifications on a two-for-one twister.

What is claimed is:

1. A hybrid yarn comprising at least two groups which are twisted together to form the yarn, the group comprising:

a first fiber group which comprises flax oilseed plant bast fibers having a tenacity of at least about 1.5 grams/Denier, a breaking elongation of from about 1 to about 20% and a crimp of from about 5 to about 80%;

a second filament group which is selected from the group consisting of synthetic fibers, natural plant fibers other than oil flax oilseed plant bast fibers and mixtures thereof, the second filament group having a fiber tenacity of above about 1.5 gram/Denier and a breaking elongation of from about 5 to about 75%;

a hydrophobic lubricant; and

a hydrophobic antistat.

2. The hybrid yarn as recited in claim 1 wherein the first fiber group and the second filament group each comprise a plurality of fibers.

3. The hybrid yarn as recited in claims **1** or **2** wherein the two groups have been twisted and each group is in an effective amount for providing a yarn with a tenacity of at least about 0.8 grams/Denier.

4. The hybrid yarn as recited in claims **1** or **2** wherein the flax oilseed plant bast fibers have a length of from about 15 mm to about 75 mm and a tensile strength of at least about 1 GPa.

5. The hybrid yarn as recited in claim 4 wherein the first and second group are ring spun into a yarn.

6. The hybrid yarn as recited in claim 1, wherein the second filament group is selected from the group consisting of polypropylene filaments, polyester filaments, polyethylene filaments, polyvinyl chloride filaments, polyurethane filaments and mixtures thereof.

7. The hybrid yarn as recited in claim 4, wherein the first group of oilseed flax bast fibers further includes an additional type of bast fiber which comes from a plant other than an oilseed flax plant.

8. A thermoformable hybrid yarn comprising:

at least two groups which are twisted together to form the yarn, the yarn comprising:

a first fiber group which comprises oilseed flax plant bast fibers having have a length of from about 15 mm to about 75 mm, a tenacity of at least about 1.5 grams/Denier, a breaking elongation of from about 1 to about 20% and a crimp of from about 5 to about 80%; and

a second filament group which comprises at least one thermoplastic filament having a melting point of at least about 10° C. and below the thermal decomposition point of the plant bast fibers, wherein the first and second group are ring spun to a yarn.

9. A thermoformable hybrid yarn as recited in claim 8, wherein the yarn further comprises a hydrophobic lubricant and antistat.

10. A thermoformable hybrid yarn as recited in claim 8, wherein the hybrid yarn is effective for forming composites which are permanently deformable.

11. A method for making a hybrid yarn comprising at least two groups, a first fiber group and a second fiber group:

mixing the first fiber group, the second fiber group, a hydrophobic lubricant, and a hydrophobic antistat to provide a lubricated fiber group; and

spinning the lubricated group,

the first fiber group comprising flax oilseed plant bast fibers having a tenacity of at least about 1.5 grams/Denier, a breaking elongation of from about 1 to about 20% and a crimp of from about 5 to about 80%,

the second filament group being selected from the group consisting of synthetic fibers, natural plant fibers other than flax bast fibers and mixtures thereof, the second filament group having a fiber tenacity of above about 1.5 gram/Denier and a breaking elongation of from about 5 to about 75%, and

the first fiber group and the second fiber group being in amounts effective for proving a yarn with a tenacity of at leat about 0.8 grams/Denier.

12. The method as recited in claim **13** wherein the flax oilseed plant bast fibers have a length of from about 15 mm to about 75 mm and a tensile strength of at least about 1 GPa.

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