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3,819,769

SPLIT FIBERS FROM BLENDS OF POLY- PROPYLENE AND POLYETHYLENE

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ABSTRACT OF THE DISCLOSURE

Split fibers exhibiting the reticular structure obtained by mechanical reduction of an extruded and stretched polymer film strip, the polymer consisting essentially of a mixture of polypropylene having more than 5% atactic content with a low-pressure polyethylene. The resulting split fibers are generally useful as continuous threads, yarns and the like or as staple fibers.

The present application is a division of Application Ser. No. 787,211, filed Dec. 26, 1968, now U.S. Pat. 3,624,194.

The production of so-called "split fibers" has been known for some time, e.g. as disclosed in German Patent specification 667,237. These split fibers are produced in a specific manner which distinguishes them from the more conventional spinning of individual filaments from a polymer melt or a polymer solution. Thus, in order to obtain split fibers, a fiber-forming polymer such as polyvinyl chloride, cellulose acetate or the like is first extruded as a relatively thin film or foil. The film is then suitably cut or broken away into narrow strips or bands and stretched several times their original length. Then, one makes use of the tendency of the film strips to split or crack in the longitudinal direction, and the strips are subjected to this splitting action, preferably by applying physical pressure, bending or flexing, using any conventional mechanical means such as brushes, twistors, abraders, rollers and the like. In general, the resulting split fibers are connected together with a network-like or reticular structure, i.e., complete separation of the split fibers from one another is not essential.

The resulting thread-like or filamentary products can be further worked into split fiber yarns, ropes, threads and the like, and can be used in conventional manner to achieve specialty fabrics or other textile products. If desired, the split fibers can be cut or otherwise reduced to staple fibers, i.e., fibers of a short staple length, which can be used alone or worked into threads and yarns with other natural or synthetic fibers.

The term "split fibers" is therefore employed herein and in the accompanying claims to identify the particular type of fibers which are produced from an extruded film which has been separated into narrow strips, stretched and split or cracked by mechanical means. Such split fibers offer certain technical advantages over the spinning of a melt or solution through spinning nozzles having round or profiled openings to form individual continuous filaments. Thus, whereas the use of such spinning nozzles requires careful separation of the individual spun filaments, the production of split fibers proceeds from an initial extrusion of a film or foil, after which this extruded product is readily reduced to split fibers. However, this technology of making split fibers has found only a limited application, in part due to the fact that various polymers do not always yield satisfactory results in terms of yielding good commercial products.

For example, it is known that one can produce split fibers from polypropylene which is recognized as a valuable fiber-forming polymer. However, in order to obtain useful products, the polypropylene must be substantially free of any atactic content, i.e. it must be an essentially isotactic polymer, one which is stereoregulated along the molecule chain. The distinction between atactic and isotactic polypropylene is explained in detail in the prior art, e.g. in the book "Polypropylene" by Kresser, Reinhold Publishing Corp., New York (1960). For purposes of the present invention, the isotactic portion of the polymer is determined as that portion which remains insoluble when the polymer is extracted with boiling n-heptane, the dissolved or extracted portion being the atactic polymer.

When using polypropylene with an atactic content of 5% or more, it will be found that extruded films or film strips of the polymer exhibit only a slight tendency to split and do not yield a satisfactory split fiber product. Also, the deformability of the polymer at the extrusion nozzle or slot in the production of the film is very poor. Moreover, the film or film strips do not stretch well in attempting to achieve the essential orientation of the polymer molecules during the conventional stretching procedure, and the polymer itself has a relatively dull and unsatisfactory appearance. For these reasons, polypropylene has not been acceptable for use in the form of split fibers, especially where there is any substantial amount of atactic polymer present therein.

Thus, in order to achieve a practical use of polypropylene in the form of split fibers, it must first be subjected to a special extraction process in order to remove the bulk of its atactic content to at least 5% and preferably to a proportion of less than 5%. However, this extraction is quite troublesome and expensive so as to substantially raise the cost of the split fibers.

In general, it is known that polypropylene can be mixed with very slight additions of other polymers, e.g. polyesters, polyamides or polystyrene, so as to use such mixtures in producing split fibers as disclosed in British Pat. No. 1,040,663. However, such additions do not materially change the necessity for using an essentially isotactic polypropylene.

One object of the present invention is to provide a process and especially a novel composition consisting predominately of polypropylene for the production of split fibers wherein the polypropylene can retain a high atactic content so as to avoid the expensive preliminary extraction of the atactic portion of the polymer. Another object of the invention is to provide novel split fibers of a polypropylene/polyethylene mixture which are considerably easier to produce and lead to highly useful fibrous products even though they retain a high content of the atactic polymer. These and other objects and advantages of the invention will become more apparent from the following detailed disclosure.

It has now been found, in accordance with the invention, that highly improved results can be achieved in the conventional production of polypropylene-containing split fibers if the individual steps of extruding the fiber-forming polymer into a film and then reducing the film to split fibers is carried out with a polymer consisting essentially of a homogeneous melt blend of a major proportion of polypropylene having an atactic content of more than 5% and a minor proportion of a high molecular weight low-pressure polyethylene. In general, the polypropylene can contain up to as much as 40% of the atactic form of the polymer, but preferably not more than 30% and most desirably about 15 to 30% by weight (with reference to the polypropylene component in the polymer mixture). Also, the polymer mixture or melt

blend should ordinarily contain at least 60% by weight of polypropylene, and especially suitable mixtures contain about 5 to 25% by weight of the low-pressure polyethylene component to about 75 to 95% by weight of the polypropylene component.

The polypropylene is prepared according to conventional processes capable of yielding a relatively high proportion of the isotactic polymer, it being understood that the polypropylene used in the present invention is an isotactic polypropylene which still contains more than 5% by weight of atactic constituents. In other words, the content inherently defines the remaining content as being that portion which is not dissolved or extracted by boiling n-heptane, i.e., the isotactic content.

The polypropylene can contain catalyst residues, e.g. titanium compounds which have been introduced for polymerization of the initial propylene monomer. It will be recognized, of course, that those catalysts are employed which favor a relatively high isotactic content in the polymer product even though the atactic content is generally more than 5%, usually from at least 10% up to about 60%. Where the initial isotactic content is less than 70%, it is preferable to carry out a relatively simple extraction of part of the atactic polymer so as to achieve an isotactic content of preferably more than 70% up to about 90-95%. In most cases, depending upon the stereoregulation effect of the catalyst, no extraction procedure is necessary. This represents a significant advantage as compared to the necessity of reducing the atactic content down to 5% by weight or less.

Of course, it is also possible to add conventional stabilizers to the polypropylene to protect it against the effects of heat, light or other irradiation. It is also self-understood that other additives may also be included in the polypropylene or the polymer mixture, e.g., dyes, pigments, fillers or the like, to the extent that such additives are compatible with the conventional production of split fibers.

The low-pressure polyethylene employed for purposes of the invention derives its name or identification as a "low-pressure" polymer from the well-known Ziegler process and similar low-pressure polymerizations of ethylene which yield especially high molecular weight products. Further data concerning the production of this low-pressure polyethylene can be found in such references as Houwink/Staverman, "Chemie und Technologie der Kunststoff II/I," pages 137 ff., Akademische Verlagsgesellschaft Geest & Portig, Leipzig (1963). The physical properties of low-pressure polyethylenes are well known and are incorporated herein by reference as fully as if set forth in their entirety. For example, such polyethylenes generally have a melt index—190° C. of more than 4.0 and exhibit a density of from 0.945 to 0.965 gm./cc.

The polypropylene and low-pressure polyethylene are preferably thoroughly admixed, e.g., before or during residence in the extruder so as to form a homogeneous melt blend within the prescribed proportions.

According to the process of the invention, split fibers can be produced from the mixture of polypropylene and low-pressure polyethylene in an especially advantageous and trouble-free operation. The polymer mixture is capable of being extruded into films or foils without exhibiting any tendency of sticking or gumming up. The deformability of the polymer mixture at the extrusion point, i.e., through the extruder die or slotted nozzle, is excellent. Furthermore, the appearance and other properties of the product are considerably better than those which can be achieved by using only polypropylene having more than a 5% atactic content, i.e., without the addition of low-pressure polyethylene.

The procedure for reducing the initially extruded film into split fibers is conventional and does not require any special measures. Thus, the initially extruded molten polymer mixture in the form of a film is first solidified in

water and/or by means of cooled rollers, and is then cut into narrow bands or strips, preferably longitudinally of the film. These bands or strips, which may have a width for example of 25 mm. to 100 mm. are then subjected to stretching in any suitable device, e.g., paired draw rolls or the like. It is generally desirable to stretch these strips to at least about 5:7 times their original length, and preferably in a draw ratio of 6:1 to 72:1. When the polymer consists solely of polypropylene with a high atactic content, frequent disturbances occur as the film and cut strips or bands pass through the cutting and stretching process, so that undesirable twisting or coiling of the filmaceous material often occurs. By comparison, the process of the invention permits these operations to be carried out in a dependable and trouble-free manner. This is of especially great advantage where one is normally processing a very large number of narrow film strips or bands.

The stretching is an important step, as is well known, so as to orient the individual film strips in a longitudinal direction and to obtain smaller strips capable of being split into a more fiber-like product. After stretching or directly in conjunction therewith, the splitting into the so-called split fibers is carried out according to conventional procedures. For example, splitting can be readily achieved by any number of processes such as, for example, twisting, brushing, blowing with a gaseous medium, drawing through an opening having a slightly narrower width than that of the individual film strip or band, turning around rollers or onto and off of a series of rollers, drawing over edges, and the like. The particular technique for reducing the film to split fibers is not of importance for purposes of the present invention.

The capacity of the polymer film, i.e., the cut and stretched strips, for splitting in a longitudinal direction can be increased in a known manner by the addition of certain chemical reagents, e.g., those which form a gas under the influence of heat and/or in combination with one of the reaction components. These and other known variations in the production of split fibers can be readily adapted and used in the process of the invention.

The split fibers and the process according to the invention are further illustrated by the following example wherein parts and percentages are by weight unless otherwise specified.

EXAMPLE

100 parts of a polypropylene with an atactic content of about 20% (the remaining 80% being insoluble in boiling n-heptane) and 20 parts of a low-pressure polyethylene (density=0.96 gm./cc.) were melt blended and extruded through a 25D extruder having a 60 mm. screw and equipped with a suitable die or extrusion slot to provide a film with a thickness of approximately 0.18 mm. The extruder was operated under the following conditions:

Temperature of the entry zone—230° C.
Temperature in the compression zone—340° C.
Temperature in the metering zone—280° C.
Pressure—110 atm.
Output—19 kg./hr.

This extruded film was then immediately cooled and solidified and then cut into individual longitudinal strips, each of which had a width of 80 mm. These strips were then stretched longitudinally on conventional draw rolls in a draw ratio of 9.5:1, i.e., 9.5 times their original length. Finally, the stretched strips were twisted to cause them to split and form the so-called split fibers. A similar splitting is achieved by strongly brushing the strips or by running them over one or more edges under tension.

In other tests, split fibers were formed while changing only the relative proportion of atactic content of the polypropylene and/or the proportion of low-pressure polyethylene admixed therewith. The best results were obtained within the preferred ranges set forth hereinabove.

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In general, the split fibers obtained according to the invention are especially distinguished by their high tensile strength, achieving values of about 5 to 5.6 grams/denier. These split fibers can be easily processed into yarns, threads, ropes, twines and a wide variety of textile materials. For example, they are especially useful as binding strands in harvesting operations, as wrapping twines or cords, as a packing material for valves or other machine parts or as a basic continuous thread or yarn for all types of fabrics and other textiles. If desired, these split fibers can be cut into staple lengths by conventional apparatus and used alone or in combination with other natural or synthetic fibers or as a filler material to provide greater strength. Other uses will be apparent to those skilled in this art.

The invention is hereby claimed as follows:

1. Split fibers having a reticular structure as obtained by mechanical reduction of an extruded and stretched film strip consisting essentially of a homogeneous mixture of a major proportion of polypropylene having an atactic content of more than 5% up to 40% and a minor proportion of a high molecular weight low-pressure polyethylene.

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2. Split fibers as claimed in Claim 1 wherein the atactic content of said polypropylene is about 15 to 30% by weight.

3. Split fibers as claimed in Claim 1 wherein said mixture contains about 5 to 25% by weight of said low-pressure polyethylene and 75 to 95% by weight of said polypropylene.

4. Split fibers as claimed in Claim 3 wherein the atactic content of said polypropylene is about 15 to 30% by weight.

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