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(54) A neutron-shielding composite fiber and a method of manufacturing same.

(57) The invention relates to new fibrous neutron-shielding material in the form of composite or bicomponent fibers having a core-and-sheath structure, comprising a fiber-forming polymer (A) as the core component, which contains at least 5% by weight of neutron-absorbing particles of up to 25 μm, preferably 15 μm and less in diameter, and at least one kind of fibre-forming polymer (B) as the sheath component, said polymer (B) being compatible with said polymer (A). The polymers (A) and (B) are preferably polyethylene or copolymers containing a major amount of polyethylene. The neutron-absorbing particles contain ^{6}Li and/or ^{10}B.

The new fibers are conventionally melt spun bicomponentially, the ratio of the melt viscosities under the spinning conditions being from 0.2 to 0.9 of the sheath polymer to the core polymer.

The fibers obtained are highly flexible and do not show any significant generation of secondary radioactive radiation so that they are highly advantageous with respect to being manufactured into protective clothing.

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A Neutron-Shielding Composite Fiber and a Method of Manufacturing Same

The present invention relates to the field of neutron-shielding materials, and in particular to fibers effectively protecting humans and neutron-sensitive objects from thermal neutrons, said fibers showing lower emission of secondary radiation while being at the same time highly flexible. The invention further relates to a method of manufacturing said neutron-shielding fibers.

In the period of rapid growth of the nuclear industries in the past one or two decades, a variety of problems have arisen with respect to the protection of the employees of nuclear plants against potential hazards caused by radioactive irradiation. For the necessary periodical maintenance and repair tasks the employees must not only be protected against intense radioactive radiation such as gamma (γ) rays, but also against even the smallest quantity of neutron rays from the nuclear reactor.

In this connection there was an urgent need to create neutron-shielding materials which are highly flexible and can easily be manufactured into protective clothing or the like, so that in case of emergency the employees can be provided with protective clothing made from such neutron-shielding material, allowing them to carry out all necessary operations in an environment where neutrons, especially thermal neutrons, might be present.

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Further, in the medical fields various attempts have been made to introduce neutron rays into medical therapy. Among the various techniques the neutron capture therapy should be mentioned; it consists of irradiating cerebral tumors with a definite quantity of neutrons so that only the tumor will be destroyed. During the surgical operation it is necessary to protect the rest of the patient's body from any neutron rays or secondary radioactivity. For this purpose neutron-shielding material of sufficient flexibility is urgently required, which does not yield any high secondary radioactivity and/or radioactive rays as a result of neutron absorption.

Up to now most neutron-shielding materials exist in the form of boards or plates comprising cadmium and boron compounds. However, such neutron-shielding boards of said materials are physically rigid and do not show any flexibility. Further, since cadmium is known to yield a considerable quantity of secondary gamma rays as a result of neutron absorption, this chemical element cannot be used to protect the human body against neutron radiation.

The Japanese Laid-Open Patent Applications Nos. 52-127597 and 52-131097 disclose neutron-shielding materials which can be formed into sheets and are made on the basis of various kinds of plastics and boron and/or lithium compounds, which in case of neutron absorption yield only small quantities of secondary gamma rays.

These products, however, are not flexible enough to be manufactured into protective clothing which could be worn by employees of nuclear plants or used for medical purposes.

The Japanese Laid-Open Patent Application No. 53-21398 discloses a method of manufacturing neutron-shielding fibers consisting of ion exchange fibers which have absorbed ionized compounds of boron and lithium, or of staple-fiber-like polymers containing boron and/or lithium compounds.

However, in the case of ion exchange fibers the finished products do not show the desired effective shielding due to incomplete absorption and fixation of the neutron-shielding ionized compounds within the ion exchange fibers or due to the fact that the ionized compounds which have been fixed may be released from said fibers during washing and rinsing operations.

The staple-fiber-like polymers also mentioned, which are obtained by jet-spinning a mixture of neutron-shielding inorganic compounds and fiber-forming polymers can physically retain their fibrous structure. However, said staple fibers cannot be processed with any known yarn-spinning and knitting or texturizing machine due to their insufficient tensile strength, elongation and fiber configuration (textured styles). In addition, said staple fibers usually carry the neutron-shielding compounds exposed on their surface so that the latter may easily be rubbed or stripped off this surface, whereby the shielding properties inevitably deteriorate.

In the course of extensive experiments with fibers composed of various fiber-forming polymers formulated with several compounds of different grading (particle size) and neutron-shielding properties, it was found that they involve various critical problems. For example, neutron-shielding compounds deposited on the surface of the fibers or incorporated into portions of the fibers adjacent to their surface were found to be easily rubbed or stripped off, thus causing certain damage to the surfaces of guide rollers or other rollers due either to staining or to abrasion. Consequently, it appeared to be impossible with the prior art methods to pro-

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duce neutron-shielding fibers of a stable quality, but also to obtain finished fibers with satisfactory mechanical properties. Further, any protective clothing made of fibers of the known type showed a loss of neutron-shielding compounds during and after washing operations and as a result of frictional forces between the clothing and various objects during its practical use. It was also found that the finished products made from prior art neutron-shielding fibers, when exposed to neutron rays, yielded significant quantities of secondary radioactive radiation and/or materials due to various nuclear reactions. For example, when lithium (Li) was used as a neutron-shielding element the lithium compounds present on the fiber surface, when exposed to thermal neutron rays, generated a significant quantity of tritium (^3H) which spread by diffusion into the atmosphere.

It is therefore one main object of the present invention to provide new fibrous neutron-shielding materials showing highly effective neutron-shielding without yielding unacceptably high quantities of secondary radiation when irradiated by neutron rays, and which can be easily produced using conventional spinning equipment and can further easily be manufactured into protective clothing.

Further objects and benefits of the present invention will become apparent from the following description in connection with the accompanying claims.

The above-specified object as well as further objects are attained by the neutron-shielding composite fiber according to the present invention, containing neutron-absorbing particles of about 25 μm maximum in diameter, said fibers being bicomponent fibers having a core-sheath structure comprising a fiber-forming polymer (A) as the core component, which contains at least 5% by weight of said particles

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of at least one neutron-absorbing compound, and at least one kind of a fiber-forming polymer (B) as the sheath component.

The fiber-forming polymer (B) must be compatible with the fiber-forming polymer (A), that is, it should bond to the core component.

The present invention further includes a method of producing said composite neutron-shielding fiber or neutron-shielding bicomponent fiber.

Preferably, the core component should contain from 10 to 60% by weight of said neutron-absorbing compound, the particles of which should most preferably have a diameter of 15 µm or less.

To obtain fibers showing the desired absorbing and working properties, the polymer (A) of the core component and the polymer (B) of the sheath component should be selected so that the ratio of the viscosity of the sheath component to the viscosity of the core component at the temperature at which the composite or bicomponent fiber or yarn is spun falls in the range of 0.2 to 0.9.

Further preferred embodiments of the present invention will become apparent from the accompanying claims and/or the following detailed description of the present invention.

The present invention makes it possible for the first time to manufacture neutron-shielding fibers that satisfactorily meet the practical requirements for neutron-shielding clothing materials in that the generation of secondary radiation is minimized whilst at the same time the new fibers show satisfactory mechanical properties or can be manufactured into clothing without losing any of the neutron-shielding components of the fibers, so that the neutron-shielding effect

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will remain stable throughout manufacturing and use of the corresponding clothing.

The textile materials made from the fibers in accordance with the present invention show sufficient flexibility to be manufactured into comparatively comfortable protective clothing.

Neutron-absorbing compounds which can preferably be used as particles in the core component of the fibers according to the present invention should be chemically stable and physically capable of effectively absorbing thermal neutrons and minimizing or eliminating the occurrence of secondary radioactive radiation such as secondary gamma rays. Such compounds are in particular compounds containing isotopes such as ^{6}Li and/or ^{10}B.

Normally, these naturally occurring isotopes exist at a rate of about 7 to 8% in the case of the isotope ^{6}Li and about 19 to 20% in the case of the isotope ^{10}B within the respective natural isotope mixtures. For the sake of the present invention, lithium compounds and/or boron compounds containing said isotopes in the normal natural ratio may be used, e.g. compounds such as lithium carbonate, lithium fluoride, boric acid, boron carbide, boron nitride, etc. It is more preferable, however, to use compounds constituted from artificially separated and enriched isotopes.

When adding said neutron-shielding compound to the core-forming component polymer (A), it is important to use a powder of said neutron-shielding compounds, consisting of particles of not more than 25 μm maximum in diameter, preferably of fine particles of 15 μm maximum in diameter or less.

If the indicated particle size ranges are not properly ob-

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served, the mixed compounds are difficult to spin into fibers, leading to poor mechanical properties of the fibers eventually obtained.

When mixing said neutron-shielding compounds with the core-forming component polymer (A), it is also an important factor that said neutron-shielding compounds are mixed into said core component polymer (A) at a rate of at least 5% by weight, preferably at a rate within the range of 10 and 60% by weight. If the content of the neutron-shielding compound in the core material is below 5% by weight, the neutron-shielding finally obtained will be lower than desired and necessary. Conversely, if the content of the neutral-shielding component in the core compound is more than 60% by weight, the spinning process will be very difficult, leading to poor mechanical properties of the fibers themselves, even though their neutron-shielding properties are improved.

For the core-forming component polymer (A), the essential component of the bicomponent fiber, a variety of widely used fiber-forming raw materials can be used, such as polyesters, polyamides, polyolefins, etc. For the aims of the present invention it is preferred to select any fiber-forming polymer which can be melt spun into fibers and/or yarns having the neutron-shielding compounds evenly distributed and dispersed within the polymer used.

From the point of view of stability with respect to neutron rays for the polymer itself, however, it is preferred and most advantageous to use polyethylene and various kinds of copolymers of polyethylene as materials for the core component (A). Polyethylene copolymers which are preferably used are copolymers containing polyethylene as their main constituent, especially copolymers consisting of polyethylene and less than 10 mol % of a second monomer, e.g. vinyl

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acetate, propylene, another alpha-olefin such as 1-butene, 1-hexene or N-vinyl carbazol.

The present invention is not restricted to the use of any specific sheath-forming polymer (B) forming the sheath of the bicomponent fiber according to the present invention, provided that the polymer used as polymer (B) is compatible with the polymer (A) used, that is, it must be properly bonded to the core-forming polymer (A). In this connection, however, it is preferred to use a sheath-forming polymer (B) which falls under the same category of polymers as the core-forming polymer (A).

It is further preferred for carrying out the present invention that the composite ratio of the core component to the sheath component fall within a range of 0.5 to 10. That is to say, if the actual composite ratio does not meet the indicated range, e.g. if the core-versus-sheath ratio exceeds a maximum of 10, the capability of the sheath-forming polymer to cover the core will become unstable so that the core component may be bared, becoming part of the surface of the obtained fiber, which will result in very critical problems. In this case part of the neutron-absorbing compounds can get lost or rubbed off in the spinning process and radioactive material secondarily generated by a nuclear reaction with absorbed neutrons can diffuse out of the fiber finally obtained.

If the core-versus-sheath composite ratio is below 10, problems such as the ones referred to above can be kept under control and substantial improvements are achieved.

However, if the core-versus-sheath composite ratio is below 0.5, the originally intended effective neutron-shielding properties of the final product cannot be obtained since the amount of the core component containing

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the neutron-shielding compounds will become too low, with respect to the sectional areas of the composite fibers.

Further, it was found that said core-versus-sheath composite ratio should preferably fall within a range of 1 to 4, thus enabling the sheath-forming polymer to cover sufficiently the neutron-shielding compounds of the core without any drop out at all, and thus sealing even the smallest quantity of radioactive materials generated by the neutron rays inside the core component polymer without any possibility of these materials escaping into the atmosphere.

Further, the diameter of the filaments obtained preferably is in the range of 5 to 200 µm, most preferably of 10 to 100 µm.

The fibers according to the present invention as disclosed above are composite or bicomponent fibers showing a marked and sufficient shielding effect in shielding humans and/or objects from neutron rays, especially from thermal neutrons.

In another aspect, the present invention relates to a process of manufacturing the core-and-sheath composite or bicomponent fibers according to the invention. It was found that, when using conventional equipment for spinning bicomponent yarns which are built up from composite or bicomponent fibers of the core-and-sheath type, said conventional equipment comprising a known spinneret for spinning conventional synthetic bicomponent fibers, the ratio of the melt viscosity X of the core-forming component polymer (A) containing the particulate neutron-shielding compounds to the melt viscosity Y of the sheath-forming component polymer (B) plays a very important role.

That is to say, when a certain melt viscosity ratio was provided under the optimum spinning temperature conditions,

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i.e. when the value of Y/X was within the range of 0.2 to 0.9, in particular, when this value was within a range of 0.3 to 0.7, it was found that the composite or bicomponent fibers of the core-and-sheath type could reliably be spun into the intended textured yarns, the quality of the obtained yarns then being very stable.

In case the melt viscosity ratio is not in the recommended range as referred to above, it is very difficult to spin the composite fibers stably according to the present invention, since the spun yarn will often be cut during the spinning process, thus disenabling the operators to perform the spinning operation satisfactorily.

The reason for the occurrence of such a phenomenon is not clear. However, the observed phenomenon is considered to be potentially peculiar to composite or bicomponent fibers of the core-and-sheath type, containing relatively large amounts of particulate additives added to the core component.

The composite fibers produced in accordance with the present invention and their secondary products, e.g. fabrics such as woven fabrics, knitted fabrics and non-woven fabrics, show very excellent neutron-shielding properties, especially with respect to shielding against thermal neutrons, without causing any intense radiation of secondary radioactive rays. The fabrics obtained do not lose any of the fixed neutron-shielding compounds by friction or during washing, and they are not only highly effective with respect to their neutron-shielding effects, they can also be easily manufactured into protective clothing for protecting humans against an attack of neutrons. Said positive characteristics are not a consequence of any secondary treatment of the fabrics obtained, but are due to the fibers themselves.

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The clothing obtained shows the mechanical properties common to any conventional fibers, also with respect to the high flexibility of the fabrics.

Therefore, protective clothing for shielding humans against neutron rays, made of the composite fibers in accordance with the present invention, satisfies a long felt need with respect to the performance of protective clothing of the present kind and is of high value in any field of the nuclear industries.

In the following examples favorable embodiments of the invention are described by way of example only.

Example 1

A total amount of 500 g of fine LiF powder, the lithium content of which consisted of more than 95% of the enriched isotope ^{6}Li and which further consisted of particles with a particle size of about 8 μm maximum in diameter and about 2.5 μm in the average cubic diameter, was mixed with a total amount of 750 g of high-density polyethylene powder (typically "HIZEX" 2100 GP, a product of Mitsui Petrochemical Company, Japan) by means of a Henschel mixer.

The mixed materials were then kneaded three times by means of an extruder (having a cylindrical diameter of 30 mm and a screw length of 500 mm) employing a screw revolution of 60 rpm and temperatures in the range of 250° to 280°C.

The mixture obtained consisted of polyethylene chips containing fine ^{6}LiF powder, the net contents of said ^{6}LiF being measured as 38.5% by weight. The melt viscosity of said polyethylene chips was measured at 260°C by means of the "KOKA" type flow tester, manufactured by Shimazu Seishakusho, Ltd., Japan, and the determined melt viscosity was 2520 poise.

Using said chips containing ^6LiF as the core component and high-density polyethylene (typically "HIZEX" 1300 J, a product of Mitsui Petrochemical Company, Japan) as the sheath component, the melt viscosity of the high-density polyethylene being measured as 1760 poise under the same testing conditions as above, core-and-sheath composite fibers were spun by means of concentric composite or bi-component spinnerets each having 12 holes with a diameter of 0.65 mm. The spinning operation was stably performed under appropriate operative conditions so that an output of 12 g per minute of the core component and of 5 g per minute of the sheath component at 260°C was obtained. The take-up speed was 450 m per minute.

The mono-filament section of the spun yarn obtained was investigated using an optical microscope with light penetration. It was found that the spun yarn obtained had evenly concentric core-and-sheath bicomponent fibers, the core component of which contained a specific amount of said fine LiF particles.

The fibers obtained were elongated at a draw ratio of 5.0 on a plate heated to 95°C. The desired continuous filaments made of core-and-sheath bicomponent fibers were successfully obtained.

These showed a tensile strength of 2.5 g per denier and 25% elongation so that they were found to show satisfactory mechanical characteristics.

The continuous filaments obtained by the preceding procedure were combined so that each of the yarns obtained contained 60 filaments, which were then processed by a knitting machine in order to make tubular knitted fabrics for testing pur-

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poses. The knitted fabric obtained showed a thickness of 1.30 mm and the area density was 490 g per square meter.

The shielding properties against thermal neutrons of this knitted fabric were evaluated. The tests were carried out in the thermal neutron standard field based on the Maxwellian distribution by means of the KUR heavy water facilities, where the shielding effect of the evaluated knitted fabrics against the broad thermal neutron rays was measured by activated gold (Au) foils. The results obtained for the neutron-shielding properties are shown in Table 1 below.

Table 1

Thermal neutron-shielding properties of knitted fabrics made of bicomponent filaments containing ^{6}LiF

No. of piled up fabrics	1	4	6	10
Thickness of the knitted fabric (mm)	1.30	5.20	7.80	13.0
Transmittance of thermal neutrons	6.4×10^{-1}	1.5×10^{-1}	4.8×10^{-2}	1.4×10^{-2}

Example 2

Analagous to the procedure of Example 1, a total amount of 750 g of fine B_4C particles (typically "DENKA BORON" No. 1200, a product of Denki Kagaku Kogyo K.K., Japan) graded on the dry basis, having a diameter of 10 µm maximum and an average cubic diameter of 3.2 µm, was mixed with a total amount of 1000 g high-density polyethylene powder (typically "HIZEX" 2100 GP, a product of Mitsui Petrochemical Company, Japan). The mixture obtained was kneaded by means of an extruder, and polyethylene chips containing uniformly distributed and dispersed fine B_4C powder were obtained. Upon analysis it was confirmed that the polyethylene chips showed a content of said B_4C powder of 42% by weight. Following the procedure of Example 1 the melt viscosity of the mixture

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obtained was measured as being 2690 poise at 260°C.

Using said polyethylene chips containing B_4C as the core component and middle-density polyethylene (typically "NEOZEX" 45300, a product of Mitsui Petrochemical Company, Japan) with a melt density of 1000 poise under the same testing conditions as above, as the sheath component, the spinning of core-and-sheath composite fibers was carried out, employing concentric composite spinnerets each having 12 holes with a diameter of 0.50 mm. The spinning operation was stably performed under the given operative conditions so that an output of 10 g per minute of the core component and of 4.5 g per minute of the sheath component was obtained at 260°C. The take-up speed was 400 m per minute.

The mono-filament sections of the spun yarns were investigated by means of an optical microscope using light penetration. The results confirmed that the spun yarns obtained consist of evenly concentric core-and-sheath composite or bicomponent fibers, the core component of which contain a specific amount of said fine B_4C particles.

The composite fibers obtained were elongated at a draw ratio of 5.5 on a plate heated to 95°C. Continuous filaments made of core-and-sheath bicomponent fibers were successfully obtained.

The filaments obtained showed a tensile strength of 2.3 g per denier and 21% elongation so that they were found to show satisfactory mechanical characteristics.

The continuous filaments obtained by the preceding procedure were combined so that the integrated yarn contained 48 filaments, and the yarn obtained was then processed by a knitting machine in order to make tubular knitted fabrics for testing purposes. The knitted fabric obtained had a

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thickness of 1.25 mm and an area density of 430 g per square meter.

The thermal neutron-shielding properties of these knitted fabrics were then evaluated. The tests were carried out using the same equipment and the same methods as in Example 1.

Table 2

No. of piled up knitted fabrics	1	4	6	10
Thickness of the knitted fabrics (mm)	1.25	5.0	7.5	12.5
Transmittance of thermal neutrons	6.0×10^{-1}	1.1×10^{-1}	4.4×10^{-2}	1.1×10^{-2}

Example 3

Analagous to the procedure of Example 1, a fine boron nitride powder (typically a product of Denki Kagaku Kogyo K.K., Japan) was mixed and kneaded with the respective amount of high-density polyethylene powder (typically "HIZEX" 1300 J, a product of Mitsui Petrochemical Company, Japan) by means of a Henschel mixer, and thus a corresponding amount of polyethylene chips containing 55% by weight of boron nitride was obtained, the melt viscosity at 250°C of the chips obtained being 2900 poise.

Using said polyethylene chips containing said boron nitride as the core component and the density polyethylene powder not containing said boron nitride, having a melt viscosity at 250°C of 2000 poise, as the sheath component, core-and-sheath composite fibers were spun. The spinning operation was stably performed at 250°C and the take-up speed was 500 meters per minute. The output ratio of the core component to the sheath component was almost 2, and the results confirmed

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that the spun yarn thus obtained had evenly concentric core-and-sheath composite fibers.

After elongating the composite fibers with a draw ratio of 4.5 on a plate heated to 95°C, very satisfactory continuous filaments having a tensile strength of 3.0 g per denier and an elongation of 32% were obtained.

The filaments obtained were then processed into a taffeta having a thickness of 0.50 mm and an area density of 250 g per square meter. Using the same equipment and methods as in Example 1, the thermal neutron-shielding properties of the taffeta obtained were tested. When 10 pieces of said taffeta were piled up to form a layer with a total thickness of 5 mm, the amount of thermal neutrons actually penetrating was determined as being 2.0×10^{-2}.

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Claims

1. Neutron-shielding composite fiber containing neutron-absorbing particles of about 25 μm maximum in diameter, c h a r a c t e r i z e d in that said fiber is a bicomponent fiber having a core-and-sheath structure, comprising
- a fiber-forming polymer (A) as the core component, which contains at least 5% by weight of said particles of at least one neutron-absorbing compound, and
- at least one kind of a fiber-forming polymer (B) as the sheath component.

2. Composite fiber according to claim 1 , c h a r a c t e r i z e d in that said particles consist of compounds containing the isotopes ^{6}Li and/or ^{10}B as essential components.

3. Composite fiber according to claim 1 or 2, c h a r a c t e r i z e d in that the fiber-forming polymers (A) and (B) consist of either polyethylene or copolymers of polyethylene as the essential constituents.

4. Composite fiber according to any of claims 1 to 3, c h a r a c t e r i z e d in that the ratio (by volume - cubic ratio) of the core component to the sheath component is in the range from 0.5 to 10.

5. Composite fiber according to any of claims 1 to 4, c h a r a c t e r i z e d in that said particles have a diameter of 15 μm maximum or less.

6. Composite fiber according to any of claims 1 to 5, c h a r a c t e r i z e d in that the core component contains between 10 to 60% by weight of said neutron absorbing compound.

7. A composite fiber according to any of claims 1 to 6, characterized in that said polymer (A) and said polymer (B) are selected from a group of fiber-forming polymers comprising high-density or middle-density polyethylene or a polyethylene copolymer containing up to 10 mol % of vinyl acetate, propylene, 1-butene, 1-hexane or N-vinyl carbazol.

8. A method of manufacturing the composite fiber according to any of claims 1 to 7, characterized in that the fiber is bicomponentially melt spun into a composite spun yarn, the melt viscosity during said melt spinning being

$$0.2 \leqq Y/X \leqq 0.9$$

wherein X is the melt viscosity of the core-forming polymer (A) including the neutron-absorbing particles, and
Y is the melt viscosity of the sheath-forming polymer (B).

9. A method according to claim 8, characterized in that the core-forming polymer (A) and the sheath-forming polymer (B) essentially consist of polyethylene or copolymers of polyethylene.

European Patent Office

EUROPEAN SEARCH REPORT

0072550
Application number

EP 82 10 7384

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	FR-A-2 212 446 (KANEBO LTD.) *Page 2, lines 1-24; page 5, lines 27-40; page 17, lines 12-30*	1,2	G 21 F 1/10 D 01 F 1/10
A	GB-A- 925 505 (GOODYEAR TIRE) *Page 3, lines 49-75,113-130; page 5, lines 50-72*	1-3	
A	US-A-3 803 453 (HULL) *Column 1, lines 30-48; column 3, lines 39-54*	1,3	
A	EP-A-0 002 227 (THE CARBORUNDUM CO.) *Page 11, lines 9-27; page 13, lines 21-27*	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	FR-A-1 034 943 (H.LUCKE et al.) *Page 1, left-hand column; page 2, abstract A*	1	G 21 F 1/10 D 01 F 1/10 D 01 F 8/06

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08-11-1982	GIANNI G.L.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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